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This project report outlines the specifications for the various aspects of the Cubberly-Lockheed Instructional System, a pilot secondary science learning system specifically for the earth/life sciences. Part I of the report presents a discussion of the general specifications for the Phase II System which emphasizes individualized instruction. Part II, Carrel Design and Performance Requirements, contains considerable data which led to the development of Carrel design specifications. Room design is discussed in Part III. Part IV considers instructional package specifications. In this part of the report instructional objectives are outlined, the testing program is discussed, and sections are devoted to teacher and student instructional responsibilities. Instructional media are discussed in Part V, and evaluation and personnel specifications are detailed in Parts VI and VII respectively. This work was prepared under ESEA Title III contract. (BC)

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CUBBERLEY/LOCKHEED SCIENCE PROJECT

FINAL REPORT

VOLUME III – PHASE II SYSTEM SPECIFICATIONS

SE 005 847

CUBBERLEY-LOCKHEED
SCIENCE PROJECT

FINAL REPORT
VOLUME III – PHASE II SYSTEM SPECIFICATIONS

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Prepared by
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PART I

GENERAL SPECIFICATION FOR THE PHASE II SYSTEM

1.0 INTRODUCTION

1.1 BACKGROUND

The central purpose of the Cubberley-Lockheed Science Project (CLSP) is to develop a pilot secondary science learning system specifically for the Earth/Life sciences. A conceptual model of the basic system is shown in Fig. 1-1. Based on a system analysis of the contemporary science program at Cubberley Senior High School, a hierarchy of four candidate systems has been defined for purposes of this study. These have been identified as Systems A, A1, B, and C.

1.1.1 System A

System A has been defined as the existing science instruction system at Cubberley. This system is characterized as a laboratory approach organized within the constraints of the self-contained classroom. Instructional modes include large-group versions of lecture, discussion, and laboratory experiences. A variety of media are employed within these modes; however, the effectiveness of this system is constrained by the lack of appropriate, readily-available software.

1.1.2 System A1

This system emerged during Phase I of the project as a result of the infusion of project-originated ideas and concepts into the existing System A instructional program. System A1 is similar to A with one significant exception: the science project itself influenced the character of on-going secondary science courses being examined by the project staff. Project impact was manifested in the areas of instructional software development, instructional methods including mode and media, and student evaluations.

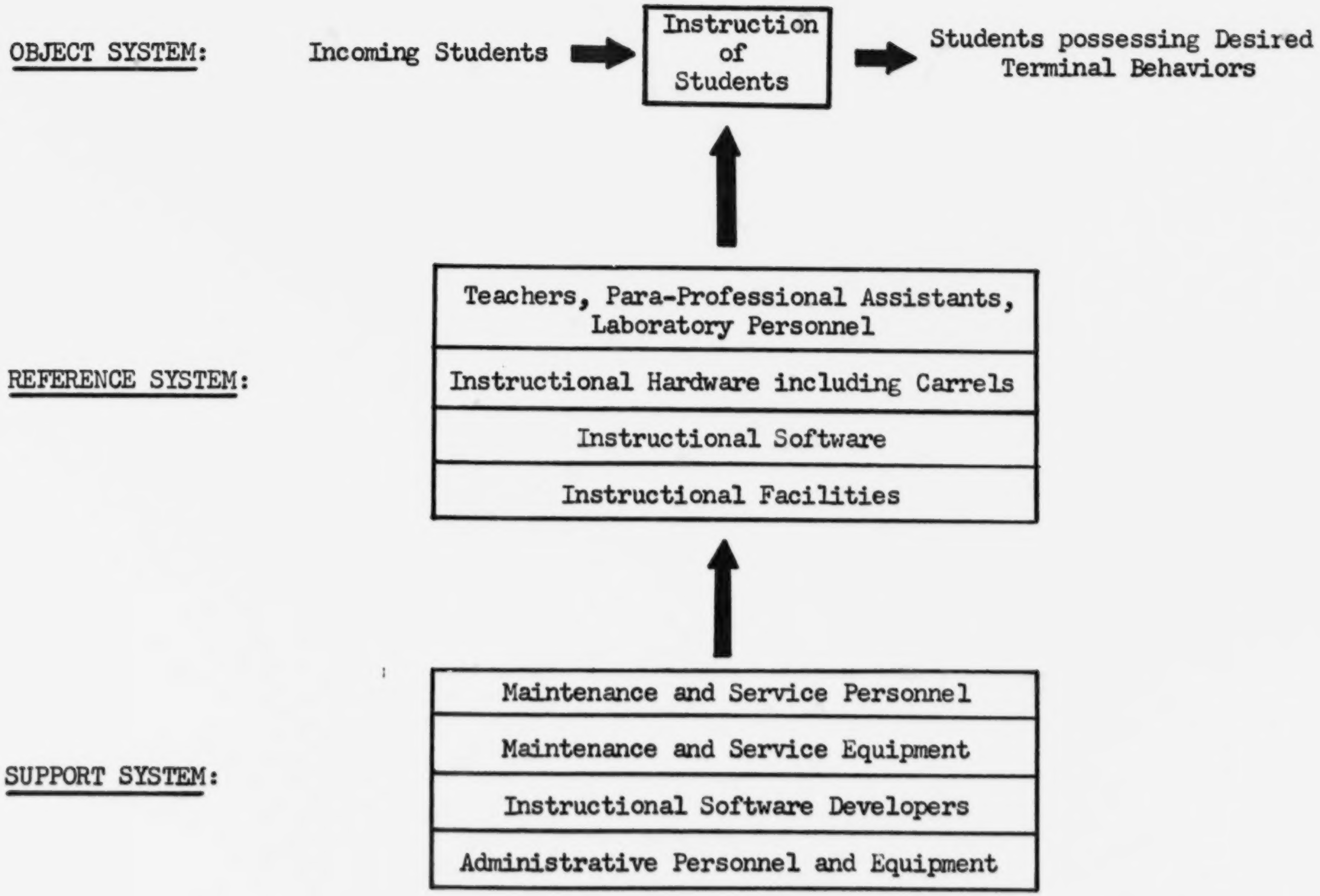
OBJECT SYSTEM:
Incoming Students
Instruction of Students
Students possessing Desired Terminal Behaviors
REFERENCE SYSTEM:
Teachers, Para-Professional Assistants, Laboratory Personnel
Instructional Hardware including Carrels
Instructional Software
Instructional Facilities
SUPPORT SYSTEM:
Maintenance and Service Personnel
Maintenance and Service Equipment
Instructional Software Developers
Administrative Personnel and Equipment

Fig. 1-1 Instructional System for Secondary Science Education

1.1.3 System B

System B represents a modest step forward from System A toward individualization of science instruction. This was accomplished by providing instructional modes supporting audio-visual presentation equipment and study environments designed to facilitate the individual instruction of each student. The principal instructional modes for this system consisted of individualized, mediated lectures; small group discussions; and individualized laboratory experiences. The basic unit of organizationin this system was the "instructional package" consisting of the complete set of instructional software required for teaching a unified sequence of content leading to the attainment of specific instructional objectives. Students were permitted to progress through the instructional package at their own rate of learning. The teacher interacted with students on a one-to-one basis, and in discussions typically involving fewer than 10 students.

1.1.4 System C

As proposed, the fourth system will resemble System B with three notable exceptions: (1) mediated instructional materials will be made available to individual study spaces or Carrels by means of a manual keyboard access stystem, (2) two-way communications via closed-circuit television will be provided between the teacher or paraprofessional supervisor and the study in the Carrel, and (3) computer support will be provided for the teacher. System C, therefore, represents the most advanced concept selected for study by the project.

1.2 SELECTION OF PHASE II SYSTEM

The system to be tested during Phase II is essentially the System B described above. This system was selected because it includes most of the aspects of the general instructional system that require empirical testing. If this system is successful, evolution to the more advanced System C could be accomplished by use of analytic techniques rather than further testing. The specifications for Phase II, therefore, contained in this document are an explication of various design aspects of System B. These specifications are contained in Parts II through VII of this document.

2.0 EQUIPMENT AND FACILITIES

The equipment and facility requirements for the Phase II system have been derived from the selected instructional modes that will be incorporated in the system. The three primary modes of instruction are:

1. Individualized independent study in a Carrel or study space.
2. Small group discussion.
3. Individualized laboratory experience.

Specifications for meeting the requirements relating to design of the study Carrels are contained in Part II of this document. Specifications for the small group discussion areas are contained in Part III. Specifications for laboratory facilities are not provided since the laboratory instruction will be conducted in existing laboratory facilities for the Phase II pilot study. Evaluations of the adequacy of laboratory facilities for this purpose will be conducted and used as inputs to the development of laboratory specifications for the operational system.

3.0 INSTRUCTIONAL PACKAGES

The instructional materials and software developed for use during Phase II shall be assembled into instructional packages in accordance with the specifications contained in Part IV of this document. Each instructional package shall be organized around a limited area of content and set of instructional objectives. Instructional packages shall contain material suitable for use in all three of the selected instructional modes of individualized study, laboratory experience and small group discussions.

4.0 INSTRUCTIONAL MEDIA AND MODES

One of the primary problems in the development of effective instructional packages is the matching of instructional media and modes to the instructional events required of the student in meeting the instructional objectives specified for the package. Although empirical data is somewhat lacking for this matching process a preliminary specification for accomplishing this function is contained in Part V of this document. It is intended that these preliminary specifications will be subjected to experimental test during Phase II and a revised specification developed for the operational system.

5.0 EVALUATION OF PHASE II

Evaluation of the Phase II program is necessary so that the effectiveness of the proposed system may be adequately tested over longer time durations than have been possible during Phase I. Evaluations shall, therefore, be accomplished in compliance with Part VI of this document and shall include both measures of academic effectiveness of the system and cost effectiveness of the system.

6.0 PERSONNEL REQUIREMENTS

Preliminary personnel requirements for manning the system are contained in Part VII of this document. These requirements have been stated in functional terms for the purposes of this document. Data collected during Phase II will permit consolidation of these functional requirements into recommended position descriptions, organizational structure, and manning tables for variously sized instructional situations.

PART II

CARREL DESIGN AND PERFORMANCE REQUIREMENTS SPECIFICATION

1.0 INTRODUCTION

1.1 SCOPE OF THE SPECIFICATION

This specification establishes design and performance requirements for an individual study Carrel and for the functional interfaces between the Carrel and other elements of the instructional system for secondary science education. The requirements of this specification shall also apply to Carrel configurations designed to accommodate two, three, or four students in those learning systems where parallel or joint study activity, and the social interaction this permits, will enhance acceptability of the study environment and contribute to the attainment of instructional system objectives.

1.2 PURPOSE OF THE CARREL

The Carrel is a small, private study space or cubicle specifically intended for individualized study of high school science topics using mediated instructional materials. The Carrell assembly is an element of the Reference System.

1.3 FUNCTIONS OF THE CARREL

The primary function of the Carrel is to provide a semi-enclosed study environment capable of accommodating one student and all of the books, resources, instructional media presentation equipment, and other materials he requires to attain specified terminal behaviors in science at his own rate of learning. Comparable work space shall be provided for each student in Carrels designed to accommodate two, three, or four students. The Carrel incorporates subsystems and environmental features for displaying selected audio-visual instructional materials under the personal control of the student.

Secondary functions of the Carrel may include individualized or parallel study without mediated instructional materials, student testing and evaluation of the attainment of instructional objectives, in-service training of professional and para-professional personnel. assessment of audio-visual materials. and instructional system development. Design and performance trade-offs involving primary and secondary functions shall be reconciled wherever possible in favor of the primary function of the Carrel.

1.4 CARREL SUBSYSTEMS AND COMPONENTS

The Carrel shall be a completely self-contained and free-standing assembly capable of being fabricated and installed in the school room or instructional facility as a unit. Figure 2-1 identifies the structural and functional subsystems of the Carrel, and the major components comprising each subsystem. Carrel subsystems and components are defined in the following paragraphs.

1.4.1 Enclosure

The principal structural component of the Carrel shall be an enclosure that visually screens the occupant and affords privacy; provides vertical surfaces for exhibiting reference materials such as maps, illustrations, charts, and other data; and provides surfaces for mounting acoustical noise attenuation materials. The enclosure shall be self-supporting, i. e. it shall not require structural attachment to the walls of the classroom or facility for support, and shall provide attachment points for the primary work surface, shelving, and other secondary load-bearing structural members. The enclosure may also be used for mounting lighting fixtures, speakers, clothing hooks. and other items of installed equipment.

1.4.2 Work Surfaces

The primary work surface shall be a horizontal writing surface located at a convenient height for reading and writing activities, the examination of natural objects, and other tasks normally performed at a conventional school desk or table. Secondary flat-topped or tiltable work surfaces may be provided to facilitate drawing. typewriting. or the display of study materials that cannot be accommodated on the primary work surface. The fixed work surfaces shall also serve as integral loading bearing members of the Carrel structure.

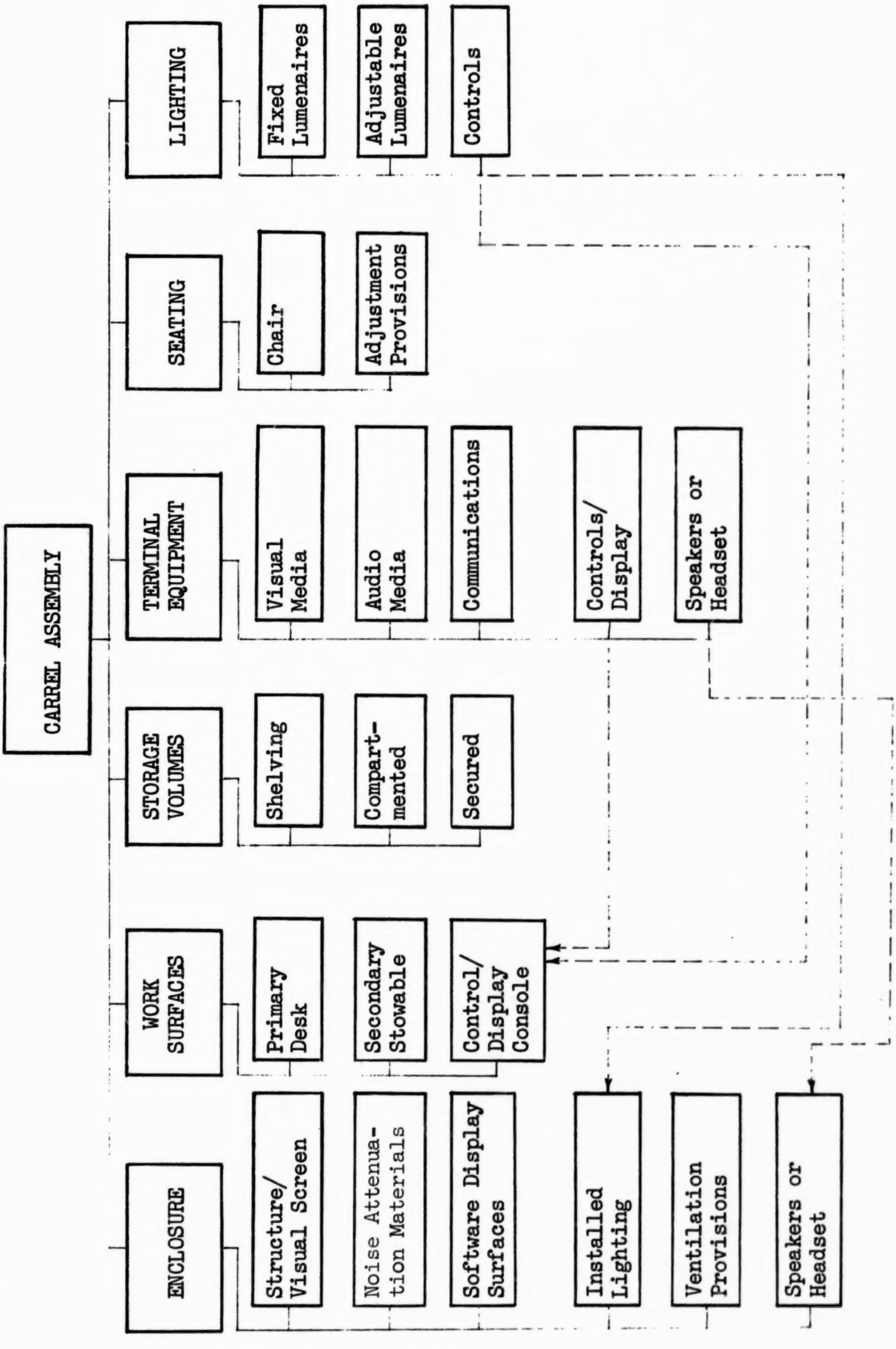
CARREL ASSEMBLY
LIGHTING
Fixed Lumenaires
Adjustable Lumenaires
Controls
SEATING
Chair
Adjustment Provisions
TERMINAL EQUIPMENT
Visual Media
Audio Media
Communications
Controls/ Display
Speakers or Headset
STORAGE VOLUMES
Shelving
Compart- mented
Secured
WORK SURFACES
Primary Desk
Secondary Stowable
Control/ Display Console
ENCLOSURE
Structure/ Visual Screen
Noise Attenua- tion Materials
Software Display Surfaces
Installed Lighting
Ventilation Provisions
Speakers or Headset

Fig. 2-1 Carrel Subsystems and Components

1.4.3 Storage Volumes

The Carrel shall incorporate integral storage volumes for instructional software including books. notebooks and reference materials; for supplies; for personal effects; and for waste paper. Shelving shall be provided at convenient heights and reach distances with respect to the writing surface for storing books and other materials that must be readily visible and accessible for frequent reference. Drawers or other enclosed compartments shall be provided for study materials and supplies that need not be visible. yet must be accessible to the seated occupant. One or more compartments shall be capable of being secured by mechanical means to permit the storage of articles to be used by the student only at the discretion of the teacher or para-professional supervisor, or for storing the student's own study materials. The compartment provided to receive waste paper must be capable of being removed and replaced readily.

1.4.4 Instructional Hardware Terminal Equipment

The Carrel shall be designed to incorporate terminal equipment for displaying audio-visual instructional software including rear-screen projection of still and motion picture imagery with and without synchronized sound. video imagery with and without sound. and magnetic sound recording playback equipment. Controls for operating terminal equipment installed in the Carrel shall be integrated into a common control panel located within the optimum reach envelope of the seated occupant. Audio-visual presentation equipment must be capable of being readily removed and reinstalled for servicing, maintenance, and repair.

1.4.5 Student/Teacher Communication Terminal Equipment

The Carrel shall incorporate voice communication terminal equipment to permit private conversations between the teacher or para-professional supervisor and the student. to permit the teacher to communicate with the occupant in a public address mode. to permit the teacher to monitor the occupant when necessary. and to permit the student to respond to audio-mediated instructional programs requiring oral participation. Audio output devices may include, but will not be limited to, binaural speakers and headset. Audio input devices may include a headset-mounted boom microphone or an installed directional microphone. Communications subsystems controls shall be integrated into a common terminal equipment control panel. Carrel terminal equipment may include a magnetic voice recording unit integrated into the communications subsystem and utilizing common audio input and output devices.

1.4.6 Seating

The Carrel occupant shall be provided with a seat specifically selected or designed to accommodate the anthropometric dimensions of the using population. It shall permit the occupant to position himself within the Carrel in those positions in which he prefers to read, write, monitor audio-visual presentations, and perform other study tasks, and to provide body support for periods up to two hours duration without discomfort or fatigue. The seat shall be free-standing, i.e. it shall not be attached to the Carrel structure, shall be castered to permit free movement, and shall be capable of being readily removed from the Carrel.

1.4.7 Lighting

The Carrel shall be equipped with lumenaires that provide general interior illumination and high intensity lighting on the primary work surface. Study lighting fixtures shall be manually adjustable in position and intensity. Controls for installed lights may be integrated into a common control panel as specified in 1.4.4.

1.4.8 Ventilation

While the Carrel shall not be equipped with an independent ventilation subsystem, provisions shall be made in the enclosure to permit ventilating air provided by the facility air conditioning system to flow through strategically placed openings in the Carrel enclosure. Audio-visual display terminal equipment requiring cooling air flow shall be installed to permit direct access to cooling air from within the Carrel. Heated air from this equipment shall not be exhausted into the interior of the Carrel.

1.5 CARREL/INSTRUCTIONAL FACILITY INTERFACES

In order for the individual study Carrel to serve its primary function effectively and economically within any existing or new secondary science instructional facility, certain functional requirements of the Carrel must be satisfied by facility subsystems. Conversely, the Carrel module must be designed to facilitate its installation in any given facility in multiples or sets that will make the most effective use of available space within the facility. These interdependent relationships or interfaces between the Carrel and the facility include environmental factors, electrical power, electronic interconnections among Carrels and between the individual Carrel and the teacher's mediation and communication console, modular installation requirements, and other considerations.

The facility shall incorporate a lighting subsystem capable of providing general area illumination ranging in intensity from that required for library activities to OFF. Floor, wall, and ceiling surfaces shall be equipped with a suitable mix of acoustic noise attenuation materials in order to maintain an acceptable noise level when all Carrels are occupied and the occupants are operating audio-visual display equipment. Facility air conditioning shall be capable of providing filtered air within the preferred range of temperatures, humidities, and flow rates for instructional facilities. This subsystem shall be capable of rejecting the incremental heat load imposed by operation of audio-visual display equipment in all Carrels.

The facility shall be equipped with an electrical power distribution subsystem sized to accommodate the demands of all facility and Carrel-installed equipment operating at maximum load. Depending upon the specific needs for flexibility, the power distribution system may be permanently installed with suitable outlets located at each Carrel site, or a flexible power distribution harness capable of being rearranged as required to accommodate Carrel operations in various temporary arrangements. Electrical and electronic interfaces between instructional hardware and communications terminal equipment may be installed in a similar manner with suitable electromagnetic interference suppression provisions and overload protection.

Applicable construction, electrical, air conditioning, and other codes for new school construction shall serve as baseline requirements. The basic facility subsystems designed in accordance with these statutory requirements must be augmented to provide the additional capability required for a fully integrated multi-Carrel instructional facility.

1.6 CARREL/SUPPORT SYSTEM INTERFACES

The Carrel shall be designed to facilitate installation, activation, maintenance, and servicing by maintenance and service personnel.

2.0 GENERAL REQUIREMENTS

2.1 SIMPLICITY OF DESIGN

Simplicity shall be a major objective of Carrel design. Structural and functional components of the Carrel shall be of the simplest design and construction that will fulfill instructional system requirements and expected school service conditions. Tradeoffs among alternative approaches to a design solution shall favor the least complicated approach wherever possible. Design or selection tradeoffs favoring simplicity will generally increase reliability and safety, assure ease of operation and maintenance, and increase the cost-effectiveness of the final Carrel design. (MIL, 6.1)* [C1]**

Ratings for design criteria are presented in Table 2-1. The ratings provide an assessment of the evidence supporting the criteria.

2.2 STANDARDIZATION

Carrel subsystems, components, controls, displays, labels, and general arrangement shall be uniform for all production models of any Carrel design developed in accordance with this specification. When two or more Carrels are installed in the same instructional facility, their subsystems and components shall be interchangeable wherever possible to permit the use of common servicing and maintenance personnel and equipment, to permit the user to follow the same procedures in operating equipment common to all Carrels, and to reduce the cost of purchasing, replacing, and repairing unserviceable equipment. (MIL, 6.1) [C1]

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*An author's name (or the abbreviation of a corporate author) and serial number appearing within parentheses identify references listed in Section 6.0 at the end of Part II.

**The code appearing within brackets refers to ratings of design criteria statements that are identified in Table 2-1. For example, [C1] indicates an excellent, common sense requirement.

Table 2-1

DESIGN CRITERIA RATING SCALES

Category/Rating	Definition
S = Supported	These criteria are supported by empirical studies and provide the most concrete bases for design requirements.
C = Common Sense	These criteria often reflect long-standing usage and acceptance and seem appropriate logically or instinctively. They emphasize the obvious and tend to reduce controversy over points that lack empirical support.
A = Arbitrary	These are criteria for which there is no empricial or logical support. Their virtue is that of providing standardization which, in turn, contributes to realiability and cost-effectiveness.
1 = Excellent	Excellent research support or unquestionable logic, or experience indicates that this is necessary.
2 = Good	Good research support or good logic, or experience indicates that this is good; deviation should be strongly justified.
3 = Fair	Incomplete or questionable research support or questionable logic, or experience indicates some success; deviation permitted with justification.

2.3 MODULAR SIZE CONSTRAINTS

Where convenience of manufacture dictates the desirability of fabricating portions of the Carrel as subassemblies, the maximum size and weight of each subassembly shall be dictated by the following constraints. Subassembly modules shall be capable of being lifted and carried conveniently by no more than two men. Modules shall weigh no more than 100 pounds. They shall be sized to fit through the frames of doors typically found in existing or new school construction. (Damon, 6.2) [C2]

2.4 SPACE LIMITATIONS

The physical size and proportions of the Carrel assembly shall be dictated by the workspace requirements of the intended occupants and maintenance personnel. It shall be no larger than is necessary to satisfy the functional requirements of this specification in order to make the most effective use of floor space for multiple Carrel installations in existing or new school construction. [C2]

2.5 VISUAL MONITORING

The Carrel enclosure and interior general arrangement shall be designed to permit the teacher or para-professional supervisor of the instructional facility to monitor student activities. Wherever possible, multiple Carrel installations shall be arranged to permit visual monitoring of the occupants of all Carrels from a central location within the instructional facility. [C1]

2.6 SAFETY

Consideration shall be given to structural, mechanical, and electrical safety factors, and to the elimination of design features that could result in injury to personnel using or maintaining the Carrel or in damage to Carrel structure or equipment. When adherence to design and performance requirements established in this specification may lead to the creation of a potential hazard to personnel or equipment, safety shall receive the heaviest weighting. Whenever cost-effectiveness analysis indicates that a Carrel design or performance requirement may be satisfied by commercially-available equipment, the selection process shall include consideration of personnel and equipment safety features. Equipment having modes of failure that could result in damage to the Carrel or injury to the user should be avoided wherever possible. (MIL, 6.1) [C1]

2.7 SANITATION

Consideration shall be given to the continuing requirement for the maintenance of Carrel cleanliness in its intended multi-usage school environment. Selection of materials of construction, surface finishes, acoustical materials, terminal equipment and other components of the Carrel shall include consideration for ease of cleaning and maintenance of adequate sanitary conditions throughout the useful life of the Carrel. [C1]

3.0 CARREL DESIGN AND PERFORMANCE REQUIREMENTS

3.1 ANTHROPOMETRIC WORKSPACE DESIGN REQUIREMENTS

To assure efficient utilization and ease of maintenance, the individual study Carrel shall be designed to accommodate the body dimensions of the student population who will use it for its primary purpose, and the professional and service personnel who will program, support and maintain its operation in the instructional facility. (Damon, 6.2) [S2]

3.1.1 Student Accommodation Requirements

The Carrel is intended to be used by students enrolled in 10th, 11th, and 12th grade science courses. The distribution of a representative sample of students in these secondary grades by age is shown in Table 2-2. The Carrel shall be designed to accommodate the largest feasible range of body dimensions of this using population:

Optimal Range of Accommodation:	2.5th to 97.5th percentile or 95 percent of the student population (Martin, 6.3) [S1]
Minimal Range of Accommodation:	5th to 95th percentile or 90 percent of the student population (Martin, 6.3) [S2]

3.1.2 Reference and Support Personnel Accommodation Requirements

Carrel subsystems and equipment that must be accessible for operation and maintenance by professional and service personnel shall be designed to accommodate the largest feasible range of body dimensions of this population.

Optimal Range of Accommodation:	5th to 95th percentile or 90 percent of the population (Damon, 6.2) [S1]
Minimal Range of Accommodation:	10th to 90th percentile or 80 percent of the population (Damon, 6.2) [S1]

Table 2-2

DISTRIBUTION OF A REPRESENTATIVE SAMPLE OF STUDENTS IN SECONDARY GRADES BY AGE, N = 902

Age*	10th Grade		11th Grade		12th Grade		Totals	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
14	1	0.3	0	0.0	0	0.0	1	0.1
15	31	10.3	0	0.0	0	0.0	31	3.4
16	176	58.3	49	16.5	0	0.0	225	24.9
17	70	23.2	195	65.7	40	13.2	305	33.9
18	22	7.3	43	14.5	203	67.0	278	30.8
19	1	0.3	9	3.0	47	15.5	57	6.4
20	1	0.3	1	0.3	12	4.0	4	0.4
21	0	0.0	0	0.0	1	0.3	1	0.1
Totals	302	100.0	297	100.0	303	100.0	902	100.0

*To Nearest Birthday (Martin, 6.3)

3.1.3 Inclusive Dimensions

Those dimensions that provide clearance such as work surface clearances over the knee and thigh, Carrel ingress/egress opening, preferred writing surface width, and other "inside" dimensions shall be based on the largest members of the population: Optimal; 97.5 percentile; Minimal: 95th percentile. (Damon, 6.2)[S1]

3.1.4 Exclusive Dimensions

Those dimensions that establish limits such as reach distances, preferred writing surface depth, seating height and other "outside" dimensions shall be based on the smallest members of the population: Optimal: 2.5th percentile; Minimal: 5th percentile. (Damon, 6.2) [S1]

3.1.5 Adjustability

Seating, tiltable work surfaces, and other Carrel features that cannot adequately accommodate the entire population if their dimensional relationships to the occupant are fixed must be adjustable to accommodate the entire range: Optimal: 2.5th to 97.5th percentile range; Minimal: 5th to 95th percentile range. (Damon, 6.2) [S1]

3.1.6 Tradeoffs

Should conflicts arise between requirements to accommodate the adult as well as the student population, student body dimensions shall be used if the tradeoff affects Carrel components to be used primarily by students. [A2]

3.1.7 Body Dimensions: Student Population

Tables 2-3 through 2-11 present the Optimal and Minimal ranges* of body dimensions for the combined male and female student population. The accompanying figures (Figs. 2-2 through 2-10) illustrate the reference points used to obtain these measurements. Measurements were obtained with students wearing light clothing appropriate for indoor school activities. (Martin, 6.3) [S1]

3.1.8 Functional Reach Requirements

Functional arm reach dimensions and preferred writing position data shall be considered critical in the design of Carrel components placed at the far limits of the study space. These data are presented in Tables 2-5, 2-9, and 2-11 [S1]

2.1.9 Handedness: Student Population

The distribution of handedness of a representative sample of students for writing and for other manual activities is shown in Table 2-12. The general arrangement of the Carrel interior, including placement of frequently used subsystems, components, controls, and other features, shall be designed to accommodate the right-handed student. The design shall be capable of being reproduced in mirror-image to accommodate left-handed students in event this is required for a specific instructional facility installation. (Martin, 6.3) [S2]

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*Preference weightings are used to indicate the degree of freedom that may exist in the application of quantitative design values. Optimal values are the most desirable. Their consistent application during Carrel design would result in an "idealized" individual study space from the point of view of those who must use it or maintain it. Minimal design values are limits beyond or below which the requirements of the instructional system, the user, or the maintainer will not be adequately satisfied and performance will be degraded.

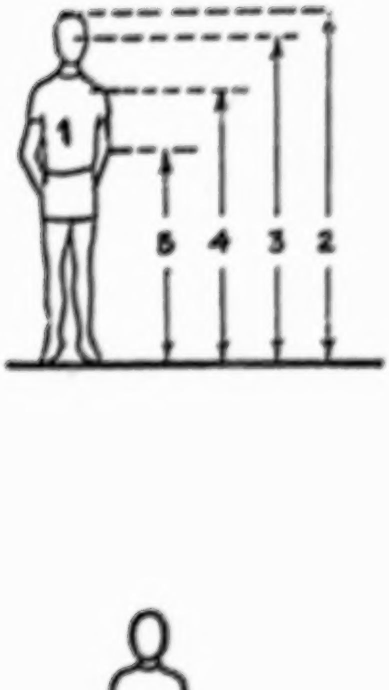
Table 2-3

HEIGHTS IN ERECT STANDING POSITION WITH SHOES[a]

No.	Measurement (in.)	Percentile					Std. Dev.
		2.5	5	50 Mean	95	97.5	
1	Weight[b]	87.4	95.4	137.6	179.8	187.8	25.59
2	Stature	60.5	61.6	67.5	73.4	74.5	3.59
3	Eye height from floor	55.7	56.8	62.7	68.6	69.7	3.59
4	Shoulder height from floor	48.7	49.8	55.2	60.6	61.7	3.30
5	Elbow height from floor	37.2	38.0	42.3	46.6	47.4	2.61
6	Wrist height	27.4	28.1	32.0	35.9	36.6	2.34
7	Fist (carrying) height	23.6	24.3	28.2	32.1	32.8	2.34
8	Finger tip height	19.6	20.3	24.2	28.1	28.8	2.34
9	Trochanteric height	28.3	29.0	32.9	36.8	37.5	2.34
10	Knee joint to sole of foot	16.1	16.6	19.1	21.6	22.1	1.42
11	Maximum upward reach	74.1	75.7	84.4	93.1	94.7	5.28

[a] Adapted from (Martin, 6.3)

[b] In pounds.



1. **Weight**: Subject wearing shoes and indoor clothing.

2. **Stature**: Subject wearing shoes and standing erect; vertical distance from top of headto floor.

3. **Eye height from floor**: Subject standing erect; distance from corner of eye to floor.

4. **Shoulder height from floor**: Subject standing erect; distance from point of arm rotation to floor.

5. **Elbow height from floor**: Subject standing erect; distance from tip of elbow to floor.

6. **Wrist height**: Subject standing erect, arm at side; distance from distal end of ulna to floor.

7. **Fist (carrying) height**: Subject standing erect, arm at side; distance from knuckle to floor.

8. **Finger tip height**: Subject standing erect, arm at side; distance from finger tip to floor.

9. **Trochanteric height**: Subject standing erect; distance from point of leg rotation to floor.

10. **Knee joint to sole of foot**: Subject standing erect; distance from point of knee rotation to floor.

11. **Maximum upward reach**: Subject standing erect, arms stretched upward; distance from finger tips to floor.

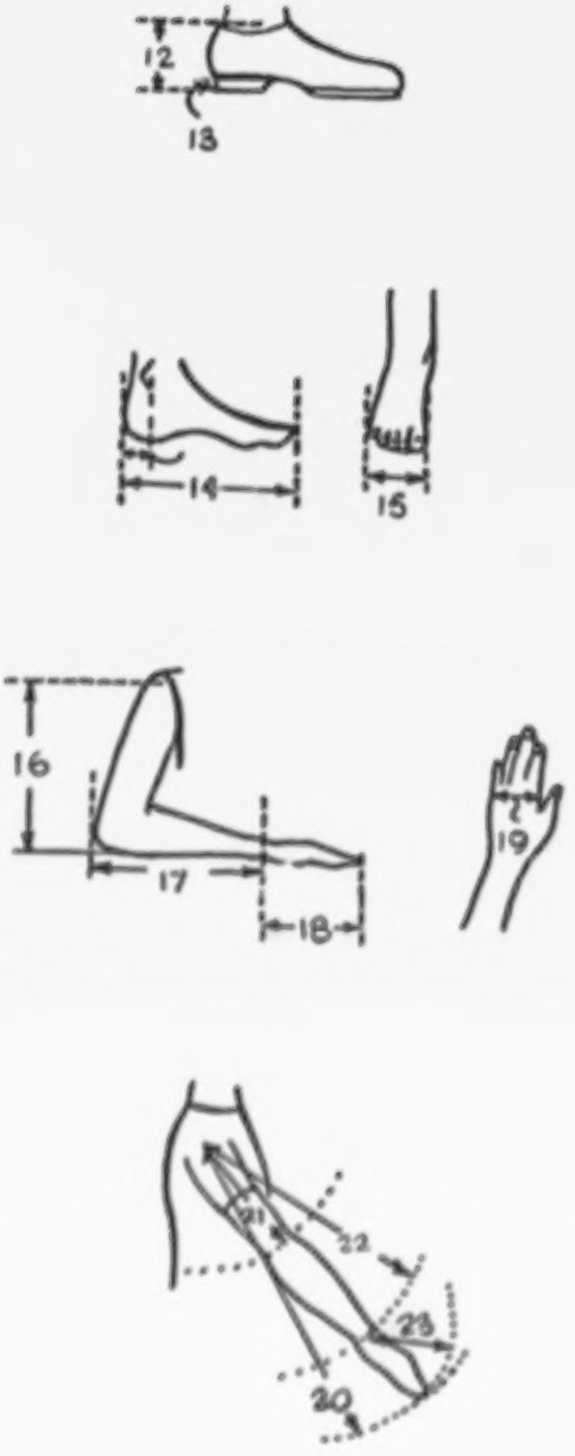
Fig. 2-2 Anthropometric Dimensions of the Student Population – Measurements 1 Through 11

Table 2-4

MEASUREMENTS OF THE FOOT, HAND, AND ARM[a]

No.	Measurement (in.)	Percentile					Std. Dev.
		2.5	5	50 Mean	95	97.5	
12	Ankle height with shoes	2.7	2.9	3.5	4.1	4.3	0.39
13	Heel of shoe height	0.3	0.4	0.8	1.2	1.3	0.23
14	Foot length without shoe	8.6	8.9	10.0	11.1	11.4	0.69
15	Foot width without shoes	2.9	3.0	3.5	4.0	4.1	0.31
16	Upper arm length	11.0	11.3	12.9	14.5	14.8	0.96
17	Elbow to wrist	9.0	9.2	10.3	11.4	11.6	0.67
18	Wrist to finger tip	7.0	7.1	7.8	8.5	8.6	0.40
19	Hand width	2.7	2.8	3.3	3.8	3.9	0.29
20	Total arm length	26.9	27.5	31.0	34.5	35.1	2.10
21	Upper arm length	11.0	11.3	12.9	14.5	14.8	0.96
22	Shoulder to wrist	20.7	21.1	23.2	25.3	25.7	1.25
23	Wrist to finger tip	7.0	7.1	7.8	8.5	8.6	0.40

[a] Adapted from (Martin, 6.3)



12. Ankle height with shoe: Distance from the floor to the right ankle.
13. Heel of shoe height: Thickness of right shoe heel.
14. Foot length without shoe: Horizontal distance from right heel to tip of longest toe.
15. Foot width without shoe: Maximum width of the right foot.
16. Upper arm length: Distance from shoulder to tip of elbow.
17. Elbow to wrist: Distance from the tip of the elbow to head of the ulna.
18. Wrist to finger tip: Distance from head of the ulna to tip of middle finger.
19. Hand width: Maximum distance across palm of the hand.
20. Total arm length: Distance from point of arm rotation to tip of middle finger.
21. Upper arm length: Distance from point of arm rotation to tip of elbow.
22. Shoulder to wrist: Distance from point of arm rotation to head of the ulna.
23. Wrist to finger tip: Distance from head of the ulna to tip of the middle finger.

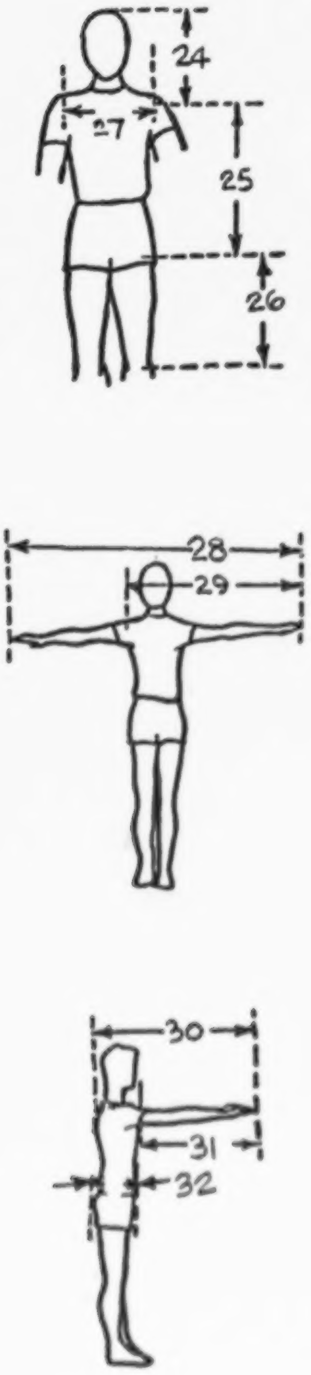
Fig. 2-3 Anthropometric Measurements of the Student Population – Measurements 12 Through 23

Table 2-5

BODY SEGMENT AND FUNCTIONAL MEASUREMENTS[a]

No.	Measurement (in.)	Percentile					Std. Dev.
		2.5	5	50 Mean	95	97.5	
24	Vertex to shoulder	10.9	11.1	12.3	13.5	13.7	0.71
25	Shoulder to trochanter	19.2	19.7	22.3	24.9	25.4	1.57
26	Trochanter to knee	11.5	11.8	13.8	15.8	16.1	1.19
27	Shoulder width	12.9	13.2	14.4	15.6	15.9	0.75
28	Maximum arm span	59.4	60.7	67.8	74.9	76.2	4.30
29	Shoulder to opposite finger	39.7	40.6	45.3	50.0	50.9	2.84
30	Back to finger tip	28.8	29.6	33.4	37.2	38.0	2.33
31	Chest to finger tip	22.6	23.2	26.5	29.8	30.4	2.00
32	Buttocks to abdomen	6.2	6.5	8.2	9.9	10.2	1.03

[a] Adapted from (Martin, 6.3)



24. Vertex to shoulder: Vertical distance from top of head to point of arm rotation.

25. Shoulder to trochanter: Vertical distance from point of arm rotation to head of femur approximately at the point of leg rotation.

26. Trochanter to knee: Vertical distance from head of femur to point of rotation of knee.

27. Shoulder width: Horizontal distance across chest between points of arm rotation.

28. Maximum arm span: Subject standing erect, arms extended sideways; distance between finger tips.

29. Shoulder to opposite finger: Subject standing erect, one arm extended sideways; distance from point of arm rotation to opposite finger tip.

30. Back to finger tip: Subject standing erect, arms extended forward; distance from scapulae to tip of middle finger.

31. Chest to finger tip: Subject standing erect, arms extended forward; distance from manubrium to tip of middle finger.

32. Buttocks to abdomen: Subject standing erect; distance from buttocks to front of abdomen.

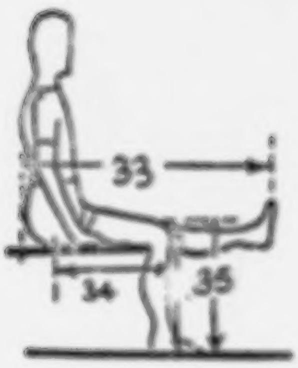
Fig. 2-4 Anthropometric Measurements of the Student Population – Measurements 24 Through 32

Table 2-6

FUNCTIONAL MEASUREMENTS

No.	Measurement (in.)	Percentile					Std. Dev.
		2.5	5	50 Mean	95	97.5	
33	Buttocks to sole of foot	31.2	31.9	35.5	39.1	39.8	2.20
34	Ischium to front of knee	17.3	17.6	19.1	20.6	20.9	0.92
35	Top of knee to sole of foot	18.1	18.6	21.1	23.6	24.1	1.52
36	Maximum seat height	14.2	14.6	17.1	19.6	20.0	1.49
37	Vertex height sitting	45.6	46.5	51.5	56.5	57.4	3.00
38	Eye height sitting	40.5	41.5	46.9	52.3	53.3	3.26
39	Shoulder height sitting	33.9	34.8	39.3	43.8	44.7	2.75
40	Elbow height	21.4	22.2	26.4	30.6	31.4	2.54
41	Lumber height	24.5	25.1	28.2	31.3	31.9	1.88
42	Thigh clearance height	19.0	19.7	23.4	27.1	27.8	2.26
43	Knee clearance height	18.1	18.6	21.1	23.6	24.1	1.52

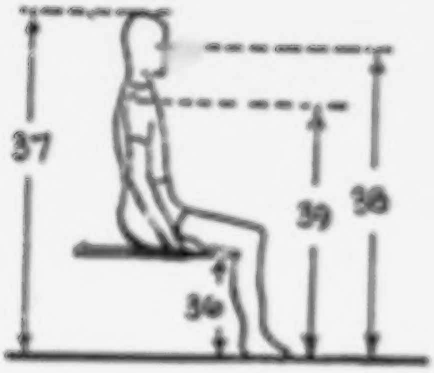
[a] Adapted from (Martin, 6.3)



33. Buttocks to sole of foot: Subject seated with one leg stretched forward; distance from buttocks to sole of foot.

34. Ischium to front of knee: Subject seated erect; distance from sitting point to front of kneecap.

35. Top of knee to sole of foot: Subject seated erect; vertical distance from top of knee to floor.

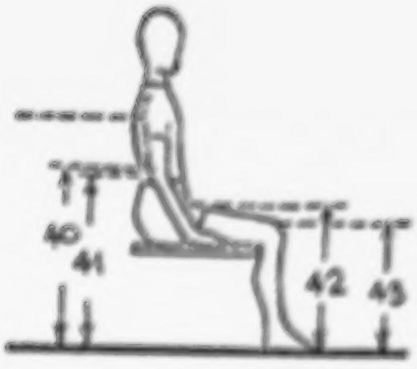


36. Maximum seat height: Subject seated erect; vertical distance from top of seat adjacent to the knees to the floor.

37. Vertex height sitting: Subject seated erect; vertical distance from top of head to floor.

38. Eye height sitting: Subject seated erect; vertical distance from corner of eye to floor.

39. Shoulder height sitting: Subject seated erect; vertical distance from point of *arm rotation to floor.*



40. Elbow height: Subject seated erect, upper arm vertical at side of body; vertical distance from tip of elbow to floor.

41. Lumbar height: Subject sitting erect; vertical distance from lumber aurve of the back to the floor.

42. Thigh clearance height: Subject sitting erect; vertical distance from top of thigh close to abdomen to the floor.

43. Knee clearance height: Subject sitting erect; vertical distance from the top of the knee to the floor.

Fig. 2-5 Anthropometric Dimensions of the Student Population – Measurements 33 Through 43

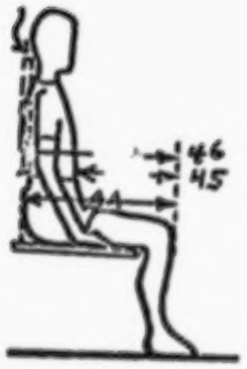
Table 2-7

SITTING POSITION MEASUREMENTS AT MAXIMUM AND MINIMUM SEAT HEIGHTS[a, b]

No.	Measurement (in.)	Percentile					Std. Dev.
		2.5	5	50 Mean	95	97.5	
44	Buttocks to front of knee	20.5	20.9	23.1	25.3	25.7	1.32
45	Abdomen to front of knee	12.2	12.6	14.7	16.8	17.2	1.26
46	Lumbar to front of knee	20.8	21.1	22.6	24.1	24.4	0.92
47	Ischium to seat front	12.9	13.2	14.7	16.2	16.5	0.92
48	Ischium to front of knee	17.3	17.6	19.1	20.6	20.9	0.92
49	Ischium to lumbar back support	2.4	2.6	3.3	4.0	4.2	0.44
50	Seat front to front of knee	2.5	2.8	4.5	6.2	6.5	1.00
51	Lumbar to seat front	16.0	16.3	17.9	19.5	19.8	0.98
52	Minimum seat height	10.5	11.0	13.3	15.6	16.1	1.41
53	Seat front to toe	18.6	19.1	21.8	24.5	25.0	1.61
54	Buttocks to toe	36.6	37.2	40.2	43.2	43.8	1.84

[a] Adapted from (Martin, 6.3)

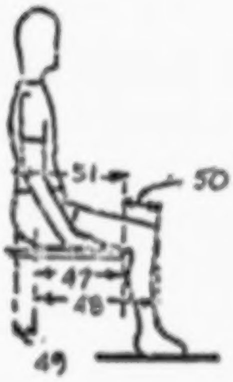
[b] Maximum seat height used for measurements numbered 44 through 51; remainder through 54 measured at minimum comfortable seat height.



44. Buttocks to front of knee: Subject sitting erect; distance from buttocks to front of kneecap.

45. Abdomen to front of knee: Subject sitting erect; distance along thigh from abdomen to front of kneecap.

46. Lumber to front of knee: Subject sitting erect; distance from the lumbar back support to front of kneecap.



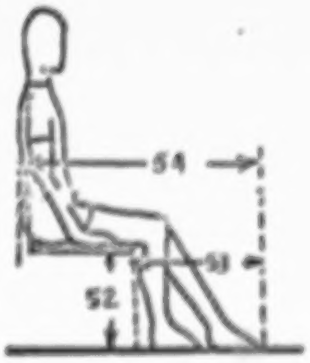
47. Ischium to seat front: Subject sitting erect; distance from sitting point to front edge of seat.

48. Ischium to front of knee: Subject sitting erect; distance from sitting point to front of kneecap.

49. Ischium to lumber back support: Subject sitting erect; distance from sitting point to front face of lumbar back support.

50. Seat front to front of knee: Subject sitting erect; distance from front edge of seat to front of kneecap.

51. Lumbar to seat front: Subject sitting erect; distance from front face of lumbar support to front edge of seat.



52. Minimum seat height: Subject seated erectly at lowest seat height at which he could keep his feet comfortably flat on the floor with legs extended forward; distance from top of front edge of seat to floor.

53. Seat front to toe: Subject seated as for 52; distance from front edge of seat to toe.

54. Buttocks to toe: Subject seated as for 52; distance from buttocks to toe.

Fig. 2-6 Anthropometric Dimensions of the Student Population – Measurements 44 Through 54

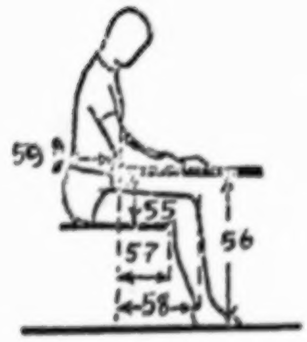
Table 2-8

MEASUREMENTS IN PREFERRED WRITING POSITION, FLAT-TOPPED TABLE[a]

No.	Measurement (in.)	Percentile					Std. Dev.
		2.5	5	50 Mean	95	97.5	
55	Table height from seat	7.8	8.1	9.6	11.1	11.4	0.90
56	Table height from floor	22.0	22.8	26.7	30.6	31.4	2.39
57	Table and seat front overlap	6.9	7.3	9.4	11.5	11.9	1.29
58	Table and knee overlap	11.4	11.8	13.9	16.0	16.4	1.29
59	Lumbar support to table edge	6.5	6.8	8.5	10.2	10.5	1.04
60[b]	Right elbow to edge of table	-1.8	-1.4	0.91	3.2	3.6	1.40
61[b]	Right elbow to centerline	7.0	7.6	10.8	14.0	14.6	1.93
62[b]	Left elbow to edge of table	-1.6	-1.3	0.60	2.5	2.8	1.13
63[b]	Left elbow to centerline	9.5	10.1	13.2	16.3	16.9	1.88
64[b]	Elbow to elbow distance	18.7	19.5	24.0	28.5	29.3	2.70

[a] Adapted from (Martin, 6.3)

[b] Measurements for eight-handed students



55. Table (elbow)height from seat: Subject seated in preferred writing position at flat-topped table; distance from top of table (elbow) to top of front edge of seat.

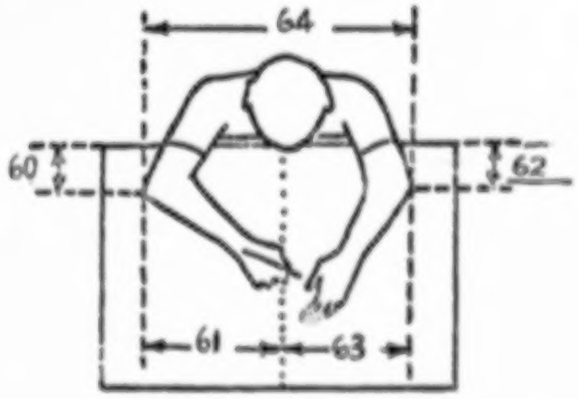
56. Table (elbow)height from floor: Subject seated as for 55; distance from top of table (elbow) to floor.

57. Table and seat front overlap: Subject seated as for 55; distance from front edge of seat to edge of table nearer student.

58. Table and knee overlap: Subject seated as for 56; distance from front of kneecap to edge of table nearer student.

59. Lumbar support to table edge: Subject seated as for 55; distance from front of lumbar back support to edge of table nearer student.

60.* Right elbow to edge of table: Subject seated as for 55; distance from tip of right elbow to edge of table nearest student.



61.* Right elbow from center of table: Subject seated as for 55; distance from tip of right elbow to centerline of table.

62.* Left elbow to edge of table: Subject seated as for 55; distance from tip of left elbow to edge of table nearest student.

62.* Left elbow from center of table: Subject seated as for 55; distance from tip of left elbow to centerline of table.

64.* Elbow-to-elbow distance: Subject seated as for 55; distance from tip of left elbow to tip of right elbow.

* Measurements for right-handed students.

Fig. 2-7 Anthropometric Dimensions of the Student Population – Measurement 55 Through 64

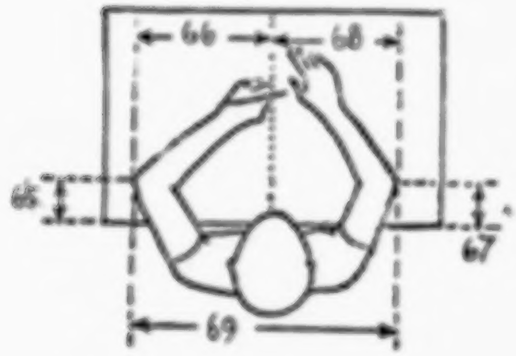
Table 2-9

MEASUREMENTS IN PREFERRED WRITING POSITION, FLAT-TOPPED AND TILTED TABLE[a]

No.	Measurement (in.)	Percentile					Std. Dev.
		2.5	5	50 Mean	95	97.5	
65[b]	Left elbow to edge of table	-2.1	-1.6	1.34	4.2	4.7	1.73
66[b]	Left elbow from center of table	9.2	9.8	12.6	15.4	16.0	1.71
67[b]	Right elbow to edge of table	-1.2	-0.9	0.46	1.9	2.2	0.86
68[b]	Right elbow from center of table	6.7	7.4	11.1	14.8	15.5	2.23
69[b]	Elbow-to-elbow distance	18.9	19.7	24.4	29.1	29.9	2.83
70	Writing arc, right hand	15.8	16.2	18.1	20.0	20.4	1.17
71.	Arc of reach in writing position, left hand	26.9	27.6	31.0	34.4	35.1	2.09
72	Seat height (one below maximum)	13.2	13.6	16.1	18.6	19.0	1.49
73	Table edge height from seat	6.9	7.3	9.1	10.9	11.3	1.10
74	Table edge height from floor	20.1	20.9	25.2	29.5	30.3	2.59

[a] Adapted from (Martin, 6.3)

[b] Measurements for left-handed students.

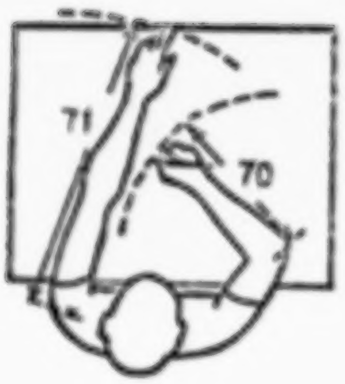


65.* Left elbow to edge of table: Subject seated as for 55; distance from tip of left elbow to edge of table nearest student.

66.* Left elbow from center of table: Subject seated as for 56; distance from tip of left elbow to centerline of table.

67.* Right elbow to edge of table: Subject seated as for 55; distance from tip of right elbow to edge of table nearest student.

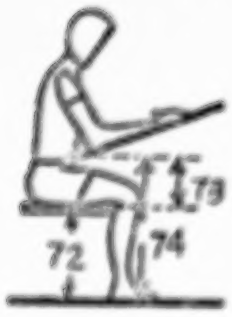
68.* Right elbow from center of table: Subject seated as for 55; distance from tip of right elbow to centerline of table.



69.* Elbow-to-elbow distance: Subject seated as for 56; distance from tip of left elbow to tip of right elbow.

70. Writing arc: Subject seated as for 55; distance from tip of right elbow to tip of middle finger with arm in writing position on table top.

71. Arc of reach in writing position: Subject seated as for 55; distance from point of left arm rotation to tip of middle finger with arm extended forward.



72. Seat height (one inch below maximum): Subject seated in preferred writing position at a desk with top inclined 20°, seat height set at 1 inch below maximum to allow freedom of movement of knees; distance from top of front edge of seat to floor.

74. Table edge height from seat: Subject seated as for 72; distance from top of edge of tilted table or desk to top of front edge of seat.

75. Table edge height from floor: Subject seated as for 72; distance from top of edge of tilted desk to floor.

* Measurements for left-handed students.

Fig. 2-8 Anthropometric Dimensions of the Student Population – Measurements 65 Through 75

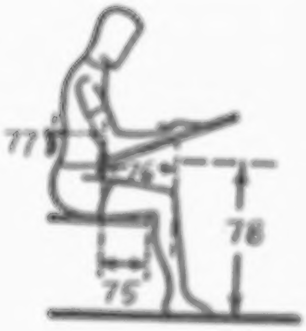
Table 2-10

MEASUREMENTS IN PREFERRED WRITING POSITION, TILTED TABLE[a]

No.	Measurement (in.)	Percentile 2.5	5	50 Mean	95	97.5	Std. Dev.
75	Table and seat front overlap	6.7	7.1	9.3	11.5	11.9	1.31
76	Table and knee overlap	11.5	11.9	14.1	16.3	16.7	1.31
77	Lumbar support to table edge	6.7	7.0	8.7	10.4	10.7	1.03
78[b]	Table (elbow) height from floor	20.4	21.2	25.5	29.8	30.6	2.59
79[b]	Right elbow to edge of table	-1.2	-0.8	0.92	2.6	3.0	1.05
80[b]	Right elbow from center of table	6.4	7.0	10.0	13.0	13.6	1.83
81[b]	Left elbow to edge of table	-1.7	-1.3	0.64	2.5	2.9	1.15
82[b]	Left elbow from center of table	8.9	9.5	12.5	15.5	16.1	1.83
83	Elbow-to elbow distance	17.4	18.2	22.5	26.8	27.6	2.58
84	Height of knee, legs crossed	21.6	22.3	26.3	30.3	31.0	2.42

[a] Adapted from (Martin, 6.3)

[b] Measurements for right-handed students

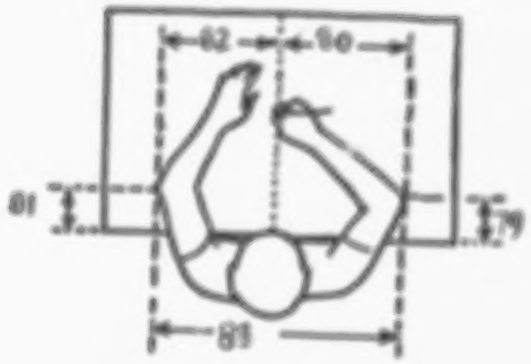


75. Table and seat front overlap: Subject as for 72; distance from front edge of seat to nearest edge of table.

76. Table and knee overlap: Subject seated as for 72; distance from front of kneecap to nearest edge of table.

77. Lumbar support to table edge: Subject seated as for 72; distance from front of lumber back support to nearest edge of table.

78. Table (elbow) height from floor: Subject seated as for 72; distance from tip of right elbow in writing position to the floor.



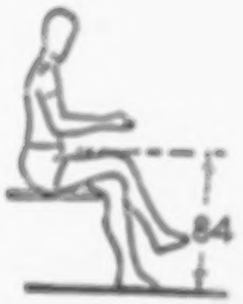
79.* Right elbow to edge of table: Subject seated as for 72; distance from tip of elbow to edge of table nearest student.

80.* Right elbow from center of table: Subject seated as for 72; distance from tip of right elbow to centerline of table.

81.* Left elbow to edge of table: Subject seated as for 72; distance from tip of left elbow to edge of table nearest student.

82.* Left elbow from center of table: Subject seated as for 72; distance from tip of left elbow to centerline of table.

83.* Elbow-to-elbow distance: Subject seated as for 72; distance from tip of left elbow to tip of right elbow.



84. Height of knee, legs crossed: Subject seated in chair with one leg crossed over the other; distance from top of upper knee to floor.

* Measurements for right-handed students.

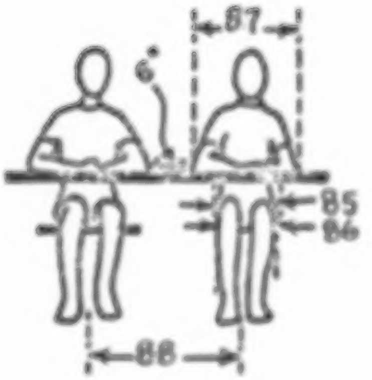
Fig. 2-9 Anthropometric Dimensions of the Student Population – Measurements 75 Through 84

Table 2-11

MEASUREMENTS IN SITTING AND REACHING POSITIONS[a]

No.	Measurement (in.)	Percentile					Std. Dev.
		2.5	5	50 Mean	95	97.5	
85	Maximum hip width	11.9	12.2	13.9	15.6	15.9	1.01
86	Width across knees	7.0	7.2	9.2	14.2	18.6	3.05
87	Elbow-to-elbow distance, fists touching	25.6	26.0	28.2	30.4	30.8	1.34
88	Spacing of chairs center to center	31.6	32.0	34.2	36.4	36.8	1.34
89	Maximum upward reach at 45 deg	66.8	68.4	77.1	85.8	87.4	5.28
90	Height of hand, arm straight forward	48.7	49.8	55.2	60.6	61.7	3.30
91	Height of hand, arm downward at 45 deg	28.7	29.4	33.3	37.2	37.9	2.34
92	Maximum space for forward reach	28.7	29.4	33.3	37.2	37.9	2.33
93	Height of hand, stooped position	6.2	6.6	9.1	11.6	12.0	1.49

[a] Adapted from (Martin, 6.3)

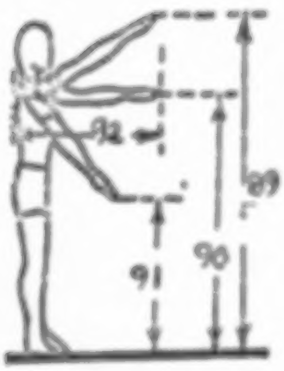


85. Maximum hip width: Subject seated erect, knees together; distance across widest part of hips.

86. Width across knees: Subject seated in preferred writing position; distance from outside of right knee to outside of left knee.

87. Elbow-to-elbow distance, fists touching: Subject leaning on table with forearms parallel to edge of table and knuckles of clenched fists touching; distance from tip of right elbow to tip of left elbow.

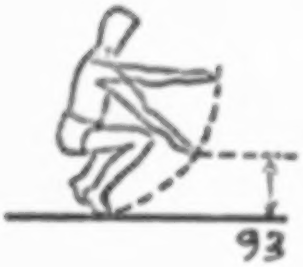
88. Spacing of chairs center-to-center: Two Subjects seated in chairs and leaning on table as for 87 with 6 in. between inside elbows; distance from center of one seat to center of other seat.



89. Maximum upward reach at 45°: Subject standing erect with arm extended upward in reaching position at 45°; vertical distance from middle finger tip to floor.

90. Height of hand, arm straight forward: Subject standing erect with arm extended straight forward in reaching position; vertical distance from middle finger tip to floor.

91. Height of hand, arm downward at 45°: Subject standing erect with arm extended downward in reaching position at 45°; vertical distance from middle finger tip to floor.



92. Maximum space for forward reach: Subject standing erect with arm extended straight forward in reaching position; distance from back to finger tips.

93. Height of hand, stooped position: Subject stooping with arm extended downward in reaching position at 45°; vertical distance from middle finger tip to floor.

Fig. 2-10 Anthropometric Dimensions of the Student Population – Measurements 85 Through 93

Table 2-12

DISTRIBUTION OF HANDEDNESS OF A REPRESENTATIVE SAMPLE OF STUDENTS FOR WRITING AND OTHER MANUAL ACTIVITIES, N = 902

Distribution of Handedness*	10th Grade		11th Grade		12th Grade		Totals	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
R/R1	273	90.5	242	81.5	248	81.8	763	84.6
R/L2	7	2.3	15	5.1	14	4.6	36	4.0
L/R3	8	2.6	14	4.7	15	5.0	37	4.1
L/L4	13	4.3	23	7.7	23	7.6	59	6.5
Not Recorded	1	0.3	3	1.0	3	1.0	77	0.8
Totals	302	100.0	297	100.0	303	100.0	902	100.0

*1. Right handed for writing and other manual activities.
2. Right handed for writing and left handed for other manual activities.
3. Left handed for writing and right handed for other manual activities.
4. Left handed for writing and other manual activities.

(Martin, 6.3)

3.1.10 Handedness: Adult Population

Carrel equipment and components to be used primarily by Reference and Support system personnel shall be designed to accommodate right-handed adults, approximately 90 percent of the adult population, except where two-handed access is required for equipment installation and servicing. (Damon, 6.2) [S2]

3.2 ENCLOSURE DESIGN REQUIREMENTS

3.2.1 Structural Requirements

The Carrel enclosure shall be a completely self-supporting, free-standing subassembly capable of transmitting all applied loads to the floor of the instructional facility. It shall not require mechanical attachment to walls or other facility structures for support. The enclosure shall provide attachment points for secondary load-bearing structural members including such components as primary work surface, shelving, storage compartments, and instructural hardware mounting structures. [A2]

3.2.2 Size

The enclosure shall be sized to accommodate the internal workspace envelope defined by work surface, storage volume, and instructional hardware accessibility requirements. It shall be no larger than necessary to satisfy the functional requirements of the student, Reference and Support System populations. Enclosure walls shall be no higher than the mean eye height from the floor of the student population in order to visually screen the occupants of adjacent Carrels. [A2]

3.2.3 Access

A rectangular opening or doorway shall be provided in the enclosure for entrance and egress. The opening shall extend the full height of the enclosure walls, and shall be free of obstructions to passage. The opening shall be sufficiently wide to accommodate the largest adult in the Reference and Support System population carrying the largest component of Carrel equipment capable of being removed from the Carrel. This component is assumed to be the seat. Minimal Opening Width: 36 in. (MIL, 6.1)[S2]

3.2.4 Modular Design

Enclosure walls or sections of walls shall be interchangeable among Carrels of identical design. They shall be capable of being assembled and disassembled using common hand tools. Walls or sections shall be capable of being carried by one adult, and shall weigh no more than 45 pounds, and shall be capable of being carried through the door frames of personnel doors typically found in existing or new school construction. (Damon, 6.2)[S2]

3.2.5 Surface Finishing

All exposed surfaces of enclosure walls shall be finished with a suitable protective surface finish capable of meeting the school service conditions anticipated and sanitation requirements specified in 2.7 above. [C2]

3.2.5.1 Noise Attenuation. Portions of exposed interior walls shall be surfaced with a noise attenuating material in order to minimize propagation or reflection of sounds produced within the Carrel by audio-visual equipment and by student responses to a voice communications or audio-mediated instructional programs.

3.2.5.2 Display Surfaces. Portions of exposed interior walls may be surfaced with a material suitable for temporarily mounting or exhibiting reference materials such as illustrations, maps, charts, schedules, and other instructional software that the student must refer to frequently in performing his study activities. The material selected shall not degrade or disintegrate with long-term use of push-pins or other mechanical fasteners, or with adhesive-backed tape for mounting display materials. [C2]

3.2.6 Lighting Equipment Interface

Interior walls may be used for mounting fixed or adjustable lumenaires to supplement general lighting installed in the instructional facility. Electrical wiring serving lighting fixtures permanently mounted to enclosure walls shall be concealed to prevent tampering and accidental damage. In the case of hollow wall construction, wiring shall be installed within the hollow core. Fixtures and lighting shall meet the general requirements of applicable underwriters codes. Lighting controls and locations are specified below. [C2]

3.2.7 Air Conditioning Interface

The enclosure shall be designed to permit air circulated by the facility air conditioning system to flow into the Carrel through strategically placed openings in addition to the entry-way. In the absence of an installed active ventilation system, i.e. blower, openings shall be placed to encourage convective ventilating air flow within the enclosure. Audio-visual and communications terminal equipment requiring cooling air shall be installed to permit direct access to cooling air from within the Carrel enclosure. Heated air from this equipment shall not be exhausted into the interior of the Carrel, but shall be be ducted to the outside of the enclosure. [C1]

3.2.8 Installed Accessories

Brackets, clothing hooks, and other small articles of hardware installed on Carrel walls shall be readily visible and accessible to the occupant, however consideration shall be given to their configuration and placement in order to avoid accidental injury during ingress, egress, and normal study activities. [C1]

3.3 WORK SURFACE DESIGN REQUIREMENTS

The Carrel shall incorporate a horizontal desk or writing surface and one or more secondary work surfaces as defined in 1.4.2 above. Student anthropometric dimensions shall be used for the design and location of these components within the Carrel. Preferred dimensions are presented in Fig. 2-11 and Table 2-13.

3.3.1 Desk Surface

The primary writing surface shall be located at the preferred height for writing and other manual tasks, and sufficiently high to provide adequate clearance over the thigh of the largest seated student: Optimal Work Surface and Thigh Clearance Heights: 97.5th percentile; minimal work Surface and Thigh Clearance Heights: 95th percentile. [S1]

3.3.2 Secondary Work Surfaces

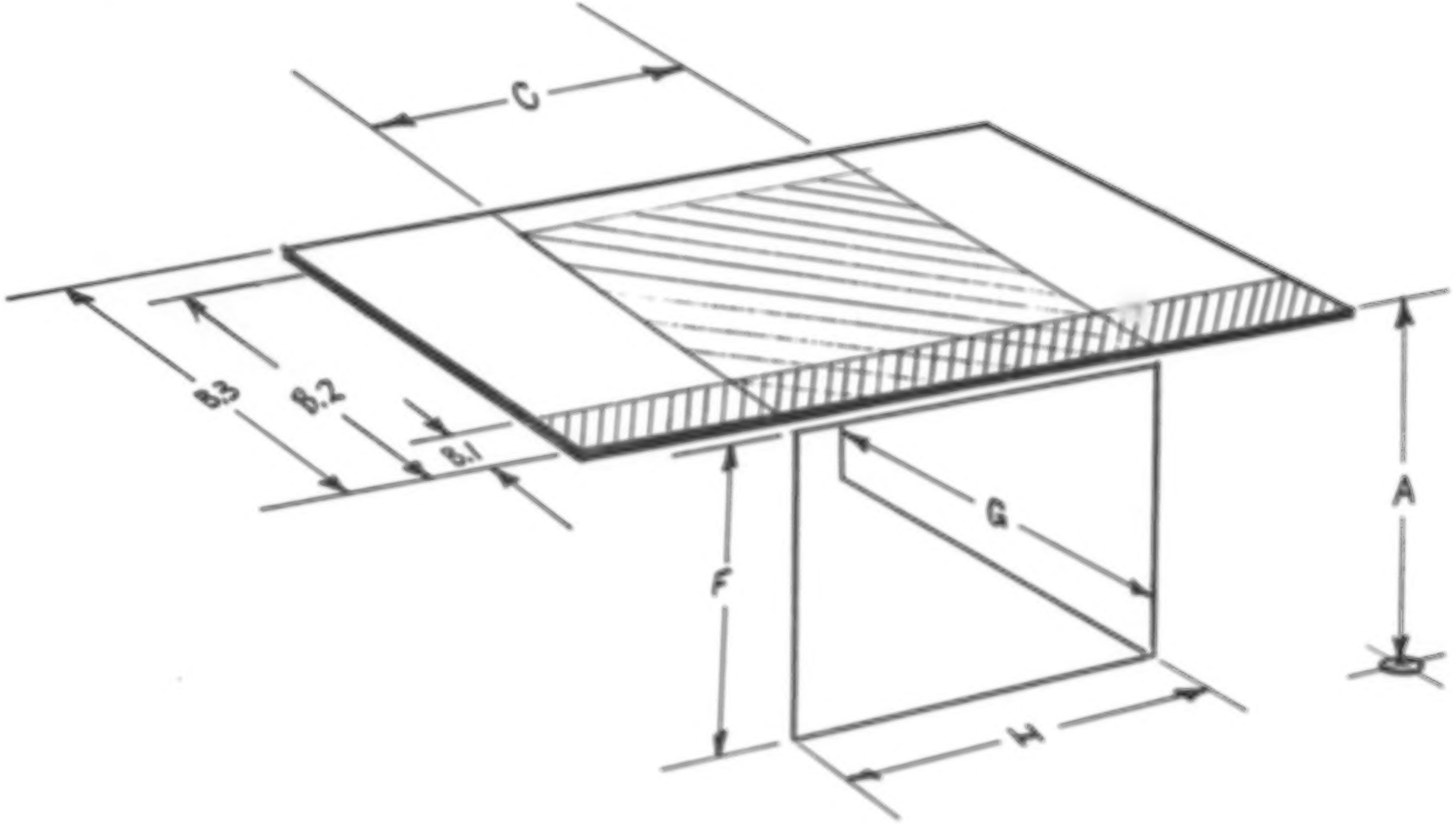
Secondary work surface and clearance heights shall conform to the requirements of 3.3.1 above. [S2]

3.3.3 Knee and Foot Room

Adequate knee and foot room shall be provided beneath the primary and secondary work surfaces to accommodate the seated student: Optimal: 97.5th percentile; Minimal: 95th percentile. (Damon, 6.2)[S1]

3.3.4 Desk Surface Dimensions

The primary work surface shall be wide enough to accommodate the largest seated occupant in this preferred writing position plus an allowance for books, notebooks, and other study materials arranged in a convenient display for ready reference: Optimal Work Surface Width: 97.5th percentile + 12 in.; Minimal Work Surface Width: 95th percentile. Work surface depth shall permit the smallest occupant to reach study materials located at the limits of his functional reach: Optimal Work Surface Depth: 2.5th percentile +12 in.; Minimum Work Surface Depth: 5th percentile functional reach. (Martin, 6.3)[S1]



For a primary work surface inclined to 20 deg from the horizontal, dimensions D. 1, D. 2, D. 3 and E are equivalent to B. 1, B. 2, B. 3 and C respectively.

Fig. 2-11 Primary Work Surface Dimensions, Flat-Topped

Table 2-13

PREFERRED PRIMARY WORK SURFACE/DESK DIMENSIONS

Primary Work Surface Dimension*	Reference Body Dimensions	Type of Dim.	Minimal Dim. (in.)	Optical Dim. (in.)	Allowance Dim. (in.)	Recommanded Dimension (in.)
A. Height of work surface	42,56,78,84	Incl	30.6	31.4	–	31.4
B. Depth of work surface, flat						
1. Elbow rest only	60,62,65,67	Incl	4.2	4.7	–	4.7
2. Writing surface	70 + B.1	Incl	24.2	25.1	–	25.1
3. Desk work area	31,70,71	Excl	27.6	26.9	+1.1	28.0**
C. Width of surface, flat	28,64,69,83, 87	Incl	29.1	29.9	+0.1	30.0
D. Depth of work surface, inclined						
1. Elbow rest only	79,81	Incl	2.6	3.0	+1.7	4.7
2. Writing surface	70 + D.1	Incl	22.6	23.4	–	23.4
3. Desk work area	31,70,71	Excl	27.6	26.9	+1.1	28.0
E. Width of work surface, inclined	28,83,87	Incl	26.8	27.6	+2.4	30.0
F. Height of kneehole	42,56,74,84	Incl	27.1	27.8	+2.0	29.8
G. Depth of kneehole	53,57	Incl	31.8	31.9	+0.1	32.0
H. Width of kneehole	85,86	Incl	14.2	18.6	+5.4	24.0

*Minimal accom. range is 90 percent; optimal accom. range is 95 percent.

**Additional allowances must be made for audio-visual displays and storage volumes in front of the occupant at work surface level.

3.3.5 Secondary Work Surface Dimensions

In view of the fact that the occupant can reposition himself within the Carrel to make convenient use of secondary work surfaces, there is no upper limit to the width of these surfaces. For practical purposes, they should be no less than 20 in. in width. A minimum depth of 12 in. is sufficient to accommodate a standard office typewriter and notebooks containing standard 8-1/2 by 11 in. paper. [A2]

3.4 STORAGE VOLUME DESIGN REQUIREMENTS

The Carrel shall incorporate visible, concealed, and secured storage volumes as defined in 1.4.2 above. Student anthropometric dimensions shall be used for the design of these components except as noted below.

3.4.1 Shelving

Shelving shall be provided for the temporary, convenient storage of books, reference materials, and other items of instructional software, natural objects, and small articles of instructional hardware that must be readily visible and accessible to the occupant. Three to four linear feet of shelf space at least 10 in. in depth should be adequate for most science program requirements. The shelf provided immediately above the primary work surface for materials that must be used frequently shall be located within the functional reach envelope of the smallest seated occupant: Optimal: 2.5th percentile; Minimal: 5th percentile. Additional shelving may be provided above the primary shelf. Study materials stored on these shelves shall be accessible to the smallest standing occupant: Optimal: 2.5th percentile; Minimal: 5th percentile. (Martin, 6.3)[S2]

3.4.2 Concealed Storage Volumes

Concealed storage volumes in the form of drawers or enclosed shelves or compartments shall be provided for study materials, personal effects, and other articles that need not be visible, yet must be readily accessible to the seated occupant. Drawers or enclosed compartments provided below the desk surface should be located for convenient use by the smallest seated occupant: Optimal: 2.5th percentile; Minimal: 5th percentile. Drawers and other enclosed compartments located outside of the functional reach of the smallest seated occupant shall be accessible to the smallest standing occupant: Optimal: 2.5th percentile; Minimal: 5th percentile. (Martin, 6.3)[S2]

3.4.3 Secured Storage Volumes

One or more drawers or compartments shall be capable of being secured by mechanical means to facilitate the storage of perishable or costly instructional software and/or hardware that is to be used by the student only under the guidance or supervision of the teacher or para-professional supervisor. Secured storage volumes shall be accessible from the interior of the Carrel, and may be located outside of the functional reach envelope of the student population. They shall be accessible to the full range of the adult Reference and Support System population: Optimal: 5th to 95th percentile; Minimal: 10th to 90th percentile. Locks or other means for mechanically securing the compartments shall be tamper-proof; alternate means of releasing or opening the compartments shall be provided in event the primary lock malfunctions. (Martin, 6.3) [S2]

3.4.4 Waste Receptacle

An integral waste receptacle shall be installed in the Carrel to eliminate the need for a separate waste basket that consumes floor space. This receptacle may be a drawer or enclosed compartment. It shall be accessible to the full range of the student population: Optimal: 2.5th to 97.5th percentile; Minimal: 5th to 95th percentile. It shall be accessible for removal and replacement by the full range of the adult population: Optimal: 5th to 95th percentile; Minimal: 10th to 90th percentile. The receptacle shall be fabricated of a fire-proof material, and shall be capable of being water-washed to maintain its cleanliness under school service conditions. [C2]

3.5 SEATING DESIGN REQUIREMENTS

3.5.1 General

The Carrel assembly shall include a chair for the occupant. It shall provide structural support for the body, and comfortable surfaces for accommodating the occupant in the range of body positions preferred for study activities. The chair shall be a self-supporting, free-standing unit, and shall not require mechanical attachment to the Carrel for structural support. It shall be capable of being removed from the Carrel for occasional use elsewhere in the instructional facility. The following requirements shall be applied to the design of new chair configurations or to the selection of commercially-available chairs intended for use with the Carrel. [C1]

3.5.2 Structural Requirements

The chair assembly shall be designed to support the weight of one adult male representing the largest number of the Reference and Support System population with a structural safety factor of 1.5: Optimal: 244 lbs × 1.5 = 366 lbs.; Minimal: 220 lbs. × 1.5 = 330 lbs.

3.5.3 Student Accommodation Requirements

The chair assembly shall accommodate the largest feasible range of the student population: Optimal: 2.5th to 97.5th percentile; Minimal: 5th to 95th percentile. Tables 2-14 and 2-15 present Optimal and Minimal dimensions for basic chair structures. (Martin, 6.3)[S1]

3.5.4 Comfort Provisions

The chair shall provide adequate support for lumbar, buttocks and thigh areas of the body for periods up to two hours duration without discomfort or fatigue. Integral or removable armrests may be provided if they do not interfere with the primary work

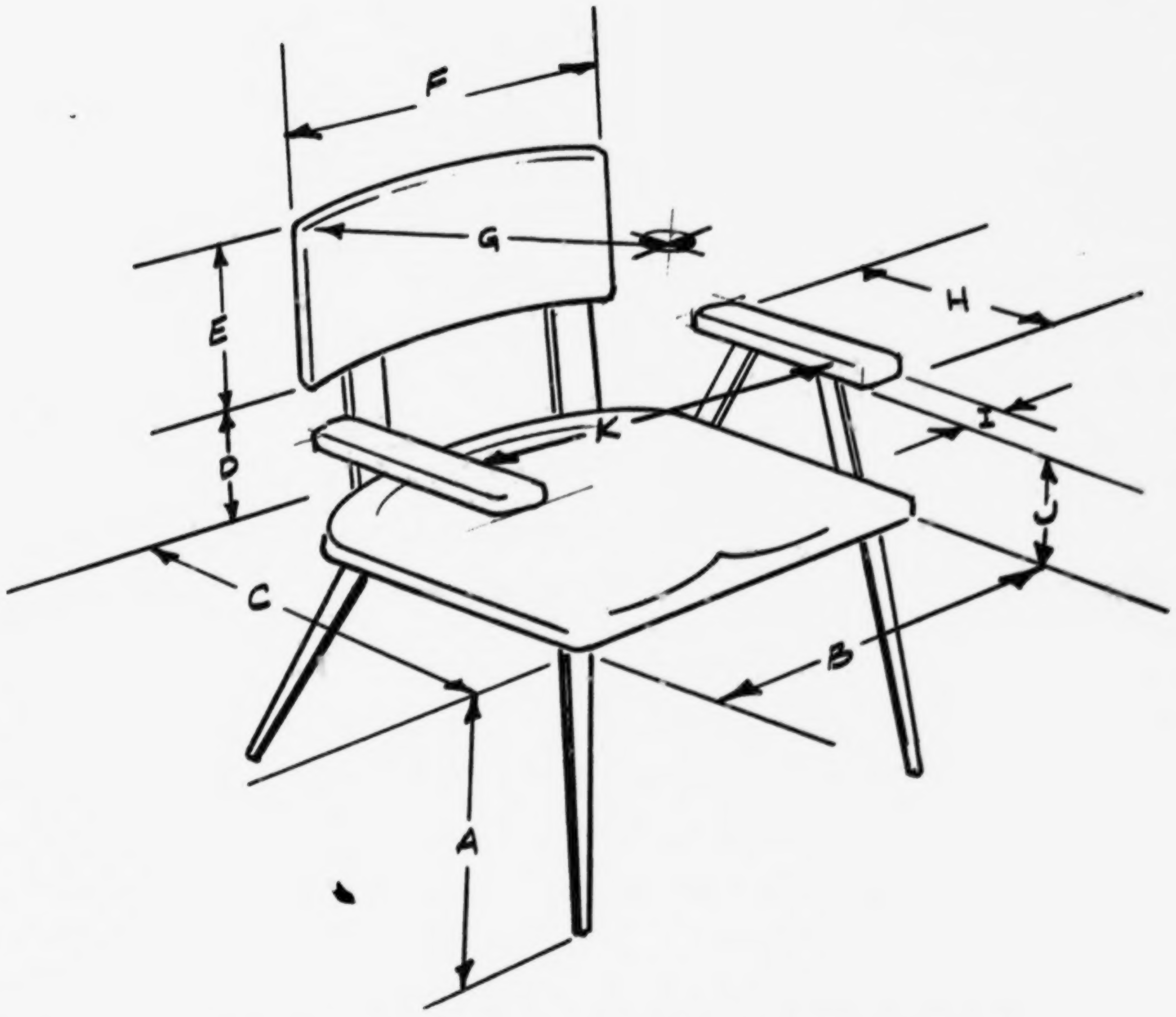


Fig. 2-12 Basic Chair Without Adjustability in Height

Table 2-14

PREFERRED SEATING DIMENSIONS

Seat Dimensions		Optimal Values (in.)	Minimal Values (in.)
A	Seat Height	17.1	13.3
B	Seat Width	16.0	15.6
C	Seat Depth	15.3	15.8
D	Backrest Space	6.0	10.3
E	Backrest Height	15.0	7.0
F	Backrest Width	16.0	15.6
G	Backrest Curve, Concave	14.0 rad	12.0 rad
H	Armrest Length	10.0	8.0
I	Armrest Width	2.0	2.0
J	Armrest Space	7.8	8.1
K	Armrest Separation	18.7	19.5

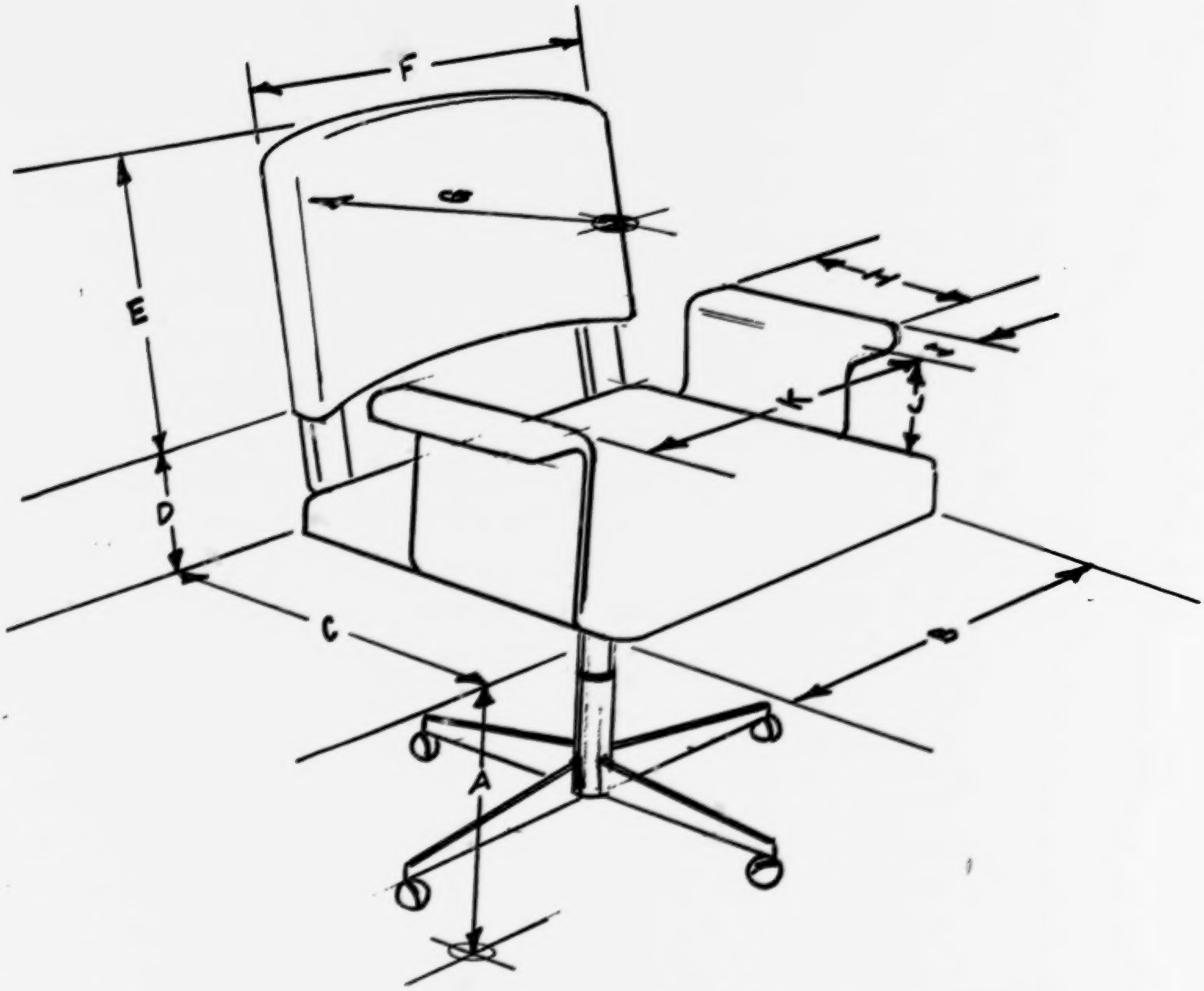


Fig. 2-13 Cushioned Study Chair With Height Adjustment Casters

Table 2-15

PREFERRED SEATING DIMENSIONS

Seat Dimensions	Optimal Values (in.)	Minimal Values (in.)
A Seat Height*	17.1**	–
B Seat Width	16.0	15.6
C Seat Depth	15.3	15.8
D Backrest Space	6.0	10.3
E Backrest Height	15.0	7.0
F Backrest Width	16.0	15.6
G Backrest Curve, Concave	14.0 rad.	12.0 rad.
H Armrest Length	10.0	8.0
I Armrest Width	2.0	2.0
J Armrest Space	7.8	8.1
K Armrest Separation	18.7	19.5

*Height may be adjusted ±2.9 in.

**Add thickness of cushioning materials (at least 1.0 in.)

surface structure and do not prevent the occupant from assuming positions preferred for writing, audio-visual display monitoring, and other study tasks involving the desk surface and associated instructional hardware. Minimal comfort provisions shall include a contoured sitting surface in the region of the ischial tuberosities, and a contoured lumbar back support. Optimal comfort provisions shall include cushioning material at least 1 in. thick on the sitting, back support, and armrest surfaces. The sitting surface shall be sloped upwared from 5 degrees (deg.) to 7 deg. from read to front. The backrest surface shall be angled backwared 13 deg to 20 deg from the vertical. This angle shall be measured from the actual or theoretical intersection of the backrest and sitting surface. Protective coverings specified for cushioned surfaces shall meet puncture and abrasion resistance requirements suitable for the intended school service conditions, and shall meet the requirements of 2.7 above. (Damon, 6.2)[S2]

3.5.5 Mobility Provisions

The Optimal study chair should be (1) adjustable in height to accommodate the largest range of the student population, (2) capable of being rotated or swiveled through 360 deg. to permit flexibility in body orientation within the Carrel, and (3) castered to permit freedom of movement within the Carrel and instructional facility irrespective of the floor covering. The Minimal chair provides none of these features, and should be avoided if at all possible. [S2]

3.6 INSTRUCTIONAL HARDWARE DESIGN REQUIREMENTS

The principal function of the Carrel is to facilitate individualized study of science topics using mediated as well as traditional study materials. The Carrel assembly must therefore incorporate instructional hardware in the form of equipment for presenting verbal and pictorial educational materials to the student. This section establishes design and performance requirements for such equipment. Provisions for displaying printed educational materials are discussed in 3.2.5.2 above.

3.6.1 Media Requirements

The primary means for presenting audio-visual mediated instructional software shall include the following:

(a) 2 in. × 2 in. 35 mm Black and White and Color Slides
(b) Standard and Super 8 mm Black and White and Color Motion Pictures
(c) Magnetic Sound Recording Tapes up to 1/4 in. in width

The Carrel shall incorporate equipment for exhibiting slides and motion picture film, and for reproducing sound recordings on magnetic tape. These may be individual items of equipment selected from commercially-available hardware, or a complete system may be developed based on the general performance requirements specified below. In either case, the equipment shall be capable of displaying slides and motion pictures with and without synchronized sound.

3.6.2 Growth Potential

During Carrel design, consideration shall be given wherever possible to the future accommodation of improved versions of the above, and to the incorporation of advanced audio-visual terminal equipment concepts. Such systems may include:

(a) Black and White and Color Closed-Circuit Television
(b) Computer-Aided Instructional System Terminal Equipment including Cathode Ray Tube Displays
(c) Centralized Magnetic Recording Broadcast System Terminal Equipment

3.6.3 Operational Requirements

In accordance with the Instructional Package Specification, a related system definition document, educational materials mediated in the form of slides, motion pictures, and magnetic tapes shall be pre-packaged and programmed in the sequence required for initial presentation to the student. In order to achieve the objective of individualized attainment of learning goals in the content area being studied, the student shall be capable of reviewing mediated instructional materials at will and, where feasible, in a random sequence. The following are Minimal and Optimal equipment control requirements for achieving individualization in media presentation.

3.6.3.1 Slide Display Equipment. Table 2-16 establishes slide presentation equipment sequence control requirements.

3.6.3.2 Motion Picture Display Equipment. Table 2-17 establishes motion picture presentation equipment sequence control requirements.

3.6.3.3 Magnetic Tape Reproduction Equipment. Table 2-18 establishes magnetic tape play-back equipment sequence control requirements.

Table 2-16

SLIDE DISPLAY EQUIPMENT CAPABILITIES

Capability	Performance Requirements	
	Minimal	Optimal
Slide Insertion	Single and Magazine	Single and Magazine
Slide Advancement	Remote Manual Control	Remote Manual Control and Automatic Timer and Coded Pulse From Magnetic Tape
Slide Reverse	Remote Manual Control	Remote Manual Control and Coded Pulse From Magnetic Tape
Random Slide Selection	Manual Indexing of Magazine or Manual Insertion of Single Slides	Remote Manual Control and Coded Pulse from Magnetic Tape
Sound Synchronization	None	Pulse Coded Magnetic Tape

Table 2-17

MOTION PICTURE DISPLAY EQUIPMENT CAPABILITIES

Capability	Performance Requirements	
	Minimal	Optimal
Film Insertion	Magazine or Cassette	Magazine or Cassette
Film Advancement/Speed	Single Frame and 16 fps and 24 fps	Single Frame and 5 through 24 fps, Remote Control
Film Reversal	Single Frame and 16 fps and 24 fps	Single Frame, and 5 through 24 fps, Remote Control
Random Frame Selection	Manual Indexing of Film or Forward/Reverse Control	Remote Control
Sound Synchronization	Photoelectric Recording	Magnetic Sound Strip with Pulse Coded Control for Random Access to Frames

Table 2-18

MAGNETIC TAPE REPRODUCTION EQUIPMENT CAPABILITIES

Capability	Performance Requirements	
	Minimal	Optimal
Tape Insertion	Magazine or Cassette	Magazine or Cassette
Tape Speed	1-7-8 fps	3-3/4 fps and 7-1/2 fps
Tape Forward/Stop	Remote Manual Control	Remote Manual Control
Tape Reverse	Remote Manual Control	Remote Manual Control
Random Access	Forward/Reverse Control	Remote Control Actuation of High-Speed Search
Sound Synchronization with Slides/Flim	Verbal Instructions of Tape	Pulse Code on Tape

3.6.4 Visual Media Display Requirements

3.6.4.1 Display Mode. The preferred mode for displaying 35 mm slides and 8 mm motion pictures within the Carrel shall be by rear-screen projection. Front-screen projection may be used only in the event projection equipment cannot be enclosed within Carrel structure for reasons of accessibility for operation, servicing and maintenance, and cost considerations. Regardless of the mode selected, projection display characteristics shall meet the requirements specified in the following sections. [A1]

3.6.4.2 Display Flexibility. At least one projection display screen shall be installed in the Carrel. It shall be designed for projecting either slides or motion pictures in any sequence without realignment of the screen or internal mirrors or other elements of the optical path. [A1]

3.6.4.3 Display Location and Arrangement. The projection display screen shall be positioned within the optimum visual envelope of the Carrel occupant, immediately above the desk surface, and slightly off the perpendicular to the student's normal line of sight to avoid direct reflections, as shown in Fig. 2-14. It shall be designed to minimize reflectance of ambient Carrel and facility lighting from the flat glass or plastic screen face (see 3.8 and 4.1.2). A hood, cowling or other device may be used to shadow the face of the screen to reduce reflection from lighting, the Carrel desk surface, and study materials. (Morgan, 6.4) [S1]

3.6.4.4 Screen Size and Proportions. The projection-display screen shall be proportioned to accommodate the formats of media specified in 3.6.1 and shown in Table 2-19 below. The physical size (height and width dimensions) of the screen may vary considerably and still be adequate for presenting mediated instructional materials. However, the determination of an optimal screen size must be based upon such factors as:

(a) Eye relief distance, i.e., distance from the student's eye to the screen
(b) The types of pictoral and printed materials to be presented
(c) The size, weight, proportions and spacing of letters and numbers to be used in printed materials to be displayed

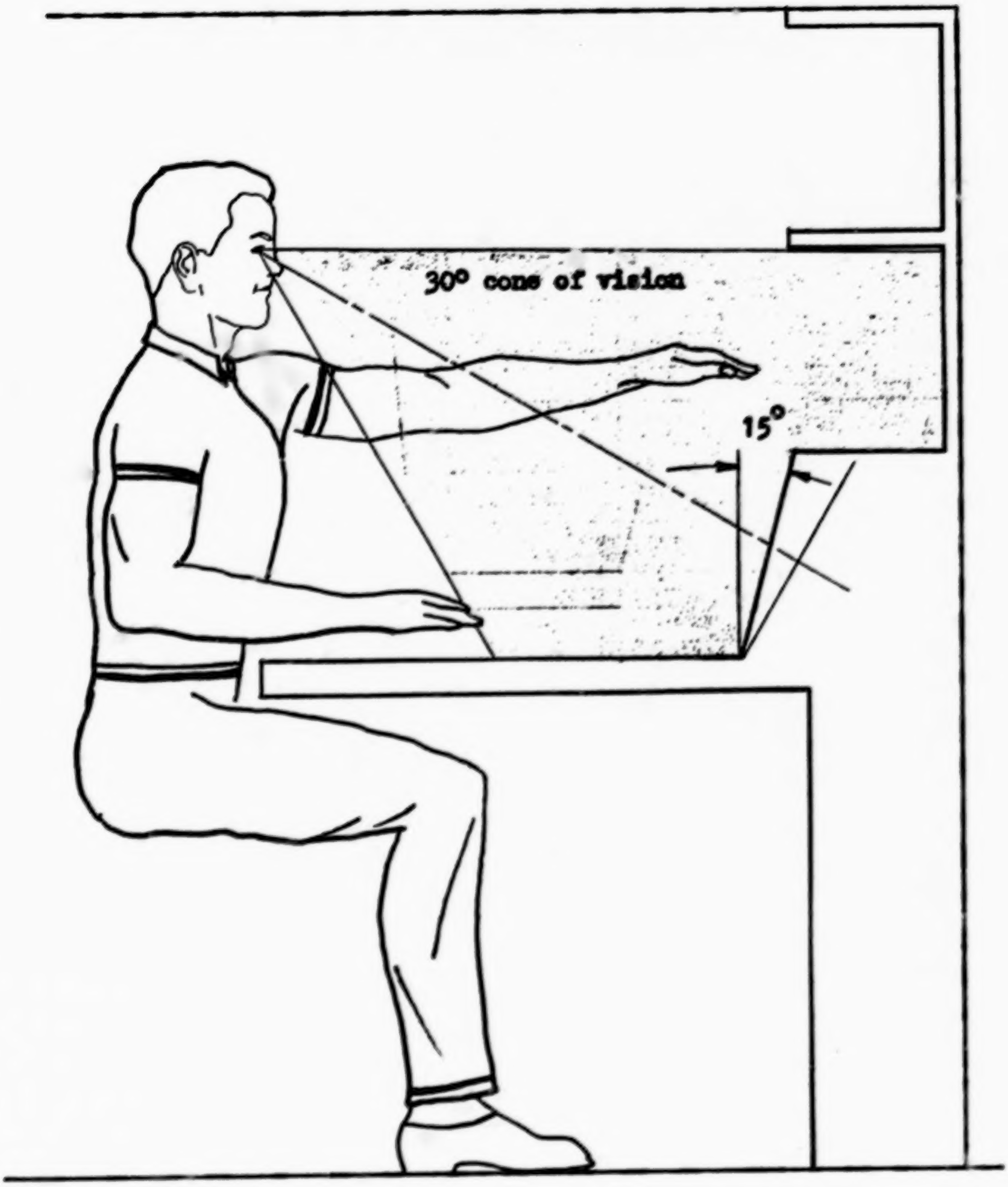

30° cone of vision
15°

Fig. 2-14 Primary Field of View

Table 2-19

PROPORTIONS OF MEDIA FORMATS

Photographic Medium	Format Width (in.)	Format Height (in.)
35 mm Slides (1.375 in. × .9375 in.)	1	0.6818
8 mm Standard Motion Pictures	1	0.736
8 mm Super Motion Pictures	1	0.75

(d) The intensity of the projected image, contrast with surrounding areas, and image contrast

(e) The distance of the screen from the projector, and characteristics of the optical system

(f) The focal length of the projection lens

Figure 2-15 illustrates the variability in width of the projected image of a 35 mm slide as a function of projection lens focal length and lens-to-screen distance. Table 2-20 presents the same data in tabular form for reference purposes. Figure 2-16 illustrates the relationship of projected image height as a function of width for the primary visual media listed in Table 2-19.

3.6.4.5 Eye Relief. The distance from the student's eyes to the display screen shall not be less than 20 in. and preferably no more than 28 in. (Damon, 6.2) [S1]

3.6.4.6 Brightness. The screen material selected shall be capable of enhancing the apparent brightness of the projected image by a minimum of 200% when the image is viewed no more than ± 5° from the normal line of sight. The brightness of Carrel areas surrounding the screen shall be variable by controlling facility and Carrel lighting intensity and shall be no greater than 50% as bright as the projected image. Image intensity shall not be controlled by varying the voltage to the projection lamp. [S2]

Table 2-20

WIDTH OF PROJECTED IMAGE OF 35-MM SLIDE AS A FUNCTION OF LENS-TO-SCREEN DISTANCE AND FOCAL LENGTH

Distance, Lens to Screen		Width of Projected Image		
in.	ft	Focal Length = 1 in.	3 in.	4 in.
6	.5	6.875		
7		8.250		
8		9.625		
9		11.000		
10		12.375		
11		13.750		
12	1.0	15.125		
13				
14		17.875		
15			5.500	3.813
16		20.625		
17			6.438	4.500
18	1.5	23.375		4.813
19			7.750	5.188
20		26.125		5.500
21			8.250	
22		28.875		6.188
23			9.188	
24	2.0	31.625	9.625	6.875
30	2.5	39.875	12.375	8.938
36	3.0		15.125	11.000
42	3.5		17.875	13.063
48	4.0		20.625	15.125
54	4.5		23.375	17.188
60	5.0		26.125	19.250

Table 2-20 (Cont.)

Distance, Lens to Screen		Width of Projected Image		
in.	ft	Focal Length = 1 in.	3 in.	4 in.
66	5.5		28.875	21.313
72	6.0		31.625	23.375
78	6.5		34.375	25.438
84	7.0		37.125	27.500

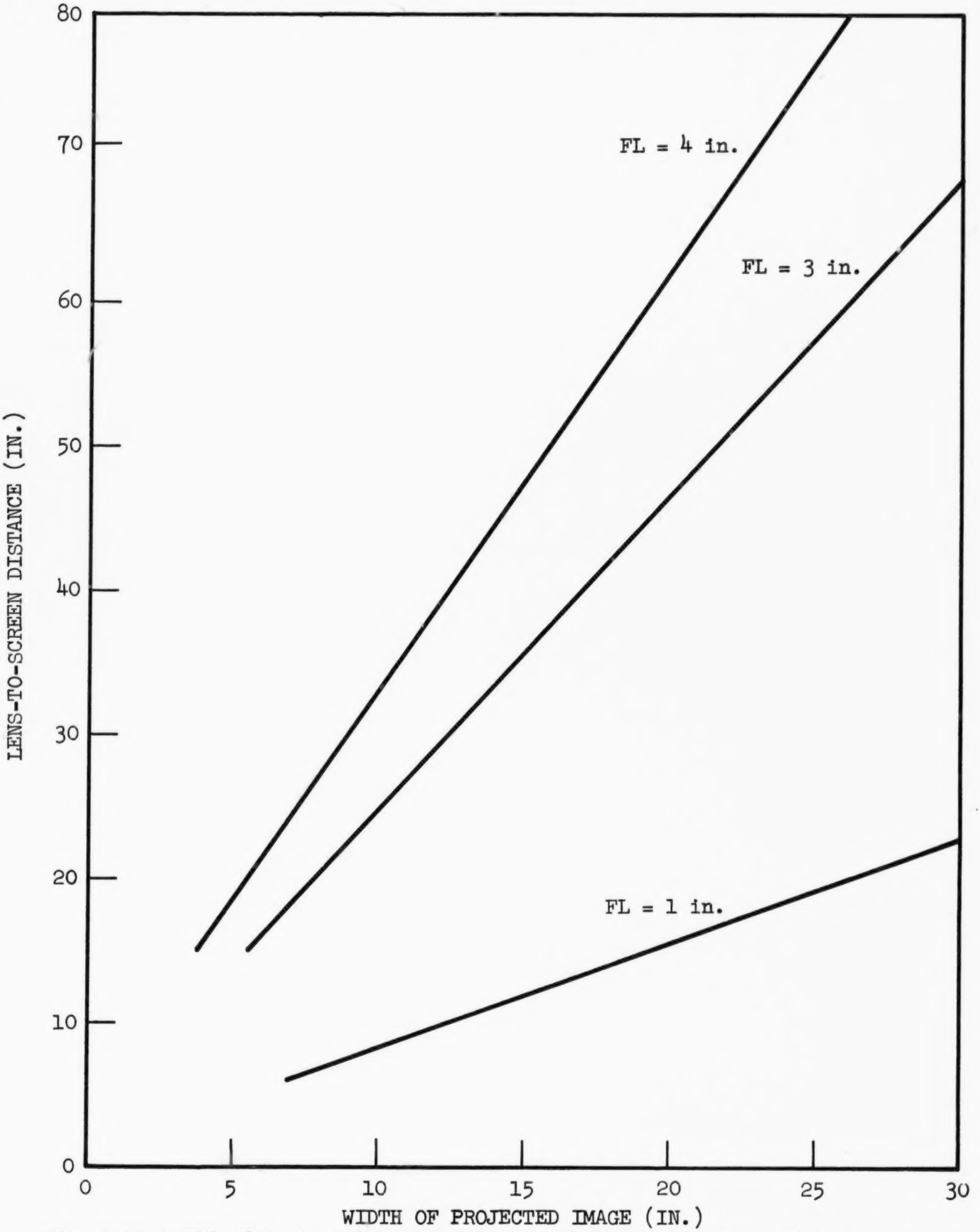


Fig. 2-15 Width of Projected Image of 35-mm Slides as a Function of Lens-to-Screen Distance and Focal Length

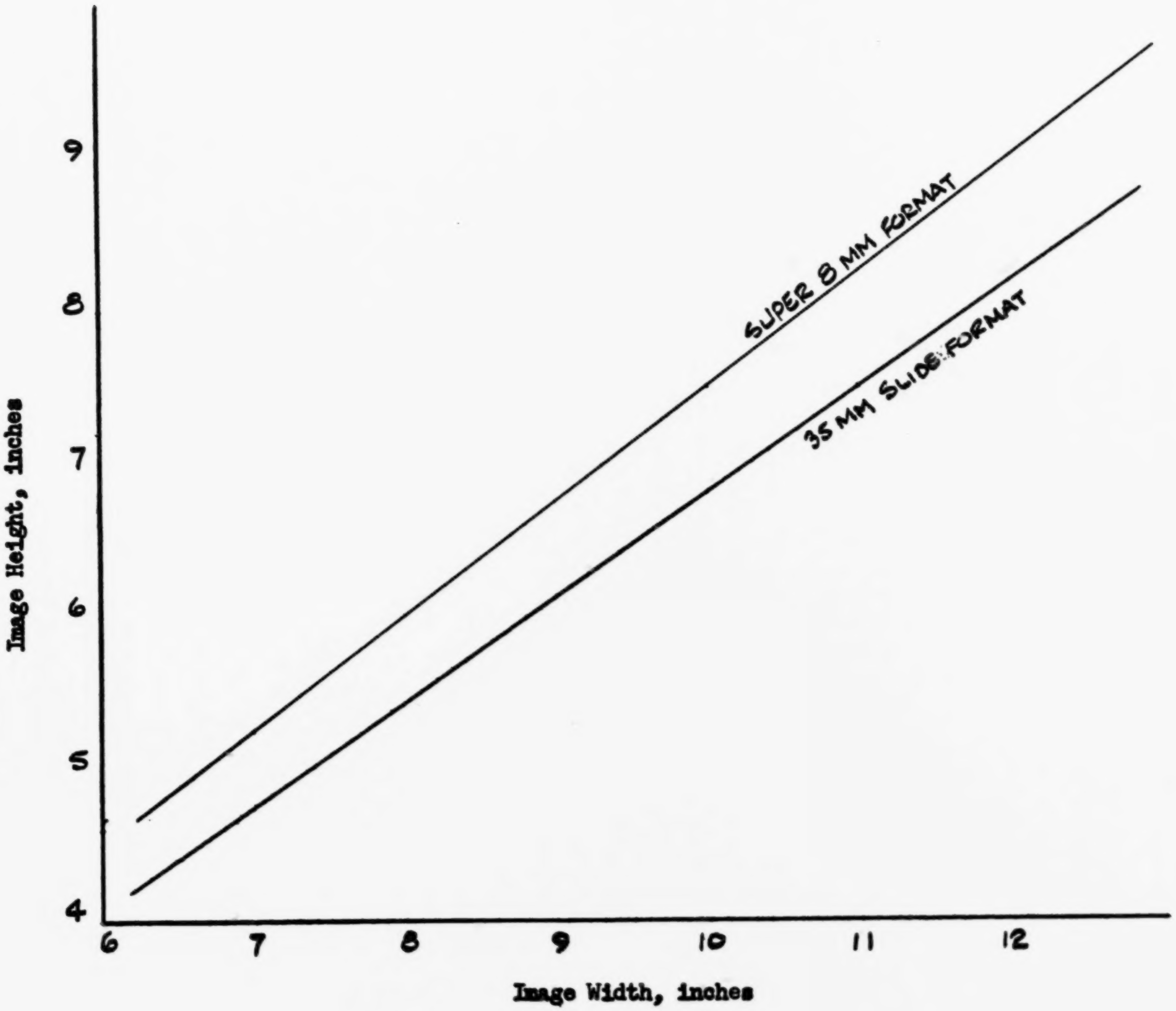


Fig. 2-16 Projection Display Image Size

3.6.4.7 Mirrors. Mirrors used to alter the path of the projected image shall be front-silvered to minimize reduction of projected image intensity. They shall be readily accessible for cleaning and adjustment from within the interior of the Carrel. [S2]

3.6.4.8 Color Fidelity. In order to insure the accurate representation of natural objects photographed under color-controlled conditions, the screen shall not alter or modify the color of projected images to the extent that they are discernible by the unaided eye. [C1]

3.6.5 Projection Display Equipment Controls

In the optimized Carrel assembly, all controls associated with each item of projection display equipment should be capable of being operated remotely, as specified in 3.6.3. This will avoid the requirement for the equipment to be completely exposed in order to gain access for manual operation of controls located on the equipment itself, conserve work surface in the primary study space, and afford other significant advantages. Where-ever possible therefore, display equipment shall be selected on the basis of its degree of operability by means of remotely-actuated controls. The following sections establish requirements for remotely-installed equipment controls.

3.6.5.1 General Arrangement. Controls for operating visual media display equipment installed in the Carrel shall be integrated into a common control panel located within the optimum reach envelope of the seated student and positioned for right-handed operation. [S1]

3.6.5.2 Organization and Layout. All controls associated with a specific equipment component shall be functionally grouped together in the same area of the panel, and arranged in a logical order based upon the sequence in which they are normally actuated. Bracketing, "pads" or other suitable methods shall be used to visually separate sub-panel areas devoted to controls for different items of equipment. For each equipment subpanel, the most frequently used controls shall be located in the most favorable position with respect to ease of reach and right-handed operation. Each subpanel shall be labeled to identify the equipment to be operated by the controls grouped in the subpanel. Labeling shall comply with the requirements of 3.6.5.6. (Morgan, 6.4)[S1]

3.6.5.3 Direction of Movement. In general, movement of a control forward, clockwise, to the right, upwards, or inward when pressing, shall turn the equipment on, advance the slide or film, move the lens of the equipment forward for focusing, increase the intensity of synchronized sound, or cause some other associated function to move forward, upward, or to the right. The converse of this direction of movement shall produce opposite or reversed results in the equipment or display being controlled. (Morgan, 6.4) [S1]

3.6.5.4 Prevention of Accident Activation. Controls shall be located so they are not susceptible to being moved or actuated accidentally in the normal sequence of equipment operation. They may be recessed, shielded, guarded, or provided with friction resistance or a lock if accidental activation out of sequence could result in damage to the equipment, significant inconvenience to the student studying the displayed materials, or personal injury. (MIL, 6.1) [S1]

3.6.5.5 Control Selection. Controls for various equipment functions should be selected or designed in accordance with the following criteria. Knobs should be used when little force is required and when precise, accurate adjustment of a continuous variable is required. Examples of applications include: volume or sound intensity and focus control. Rotary selector switches should be used for discrete functions when three or more detented positions are required; they shall not be used for a two position function. Examples include: random slide selection, motion picture projection speed, and automatic timing interval. Push buttons should be used when a control or array of controls is needed for momentary contact in a high-frequency-of-use situation. Example: slide advance. Toggle switches should be used for those functions which require two discrete positions. Examples include: forward-reverse and on-off. Detailed requirements for the design, performance, and placement of such controls are presented in (Morgan, 6.4) and (Woodson, 6.5), and will not be included here. [S1]

3.6.5.6 Labeling. All controls for each item of equipment shall be appropriately and clearly labeled. Labels shall be oriented horizontally so they may be read from left to right, shall be placed on or directly above the associated control, and shall be as concise as possible without distorting the meaning of the information. Capital letters shall be used throughout, and abbreviations shall be used only where necessary to conserve space or to improve understanding. Words shall be chosen on the basis of their familiarity to the student, and shall indicate the functional result of the control movement: advance, increase, on. In general, black letters or numerals shall be used on a light background to insure high contrast and legibility. When commercially available type styles are selected, letters should be block type without serifs and should approximate Futura, Airport Semi-Bold or Groton Extended. Numerals should approximate Futura Medium, Tempo Bold or Groton Condensed. Labels may be etched, silk-screened, engraved, and applied in any medium that will be durable and minimize wear and obscurement under school service conditions. Detailed requirements and additional criteria are presented in (Morgan, 6.4) and (Woodson, 6.5). [S1]

3.6.6 Visual Media Packaging

Instructional software to be presented using projection display equipment shall be capable of being pre-packaged by Reference System personnel in self-contained magazines or cassettes suitable for insertion and automatic operation in the equipment installed in the Carrel. [C1]

3.6.6.1 Slide Packaging. Interchangeable trays or magazines compatible with the projection display equipment shall be used for organizing and presenting slides in the preprogrammed sequence required by the instructional package. Magazines varying in capacity from 20 to 100 slides shall be capable of being used with the equipment, depending upon the needs of the instructional package. Trays shall be equipped with a dust cover and a retention device to prevent slides from falling out if the tray is overturned. Slots shall be numbered in sequence beginning with the first to be indexed for projection. Trays or magazines shall be capable of being inserted into and removed from the projector with ease by a seated student. [C1]

3.6.2.2 Motion Picture Film Packaging. Interchangeable cartridges or cassettes compatible with the projection display equipment shall be used for motion-picture mediated instructional materials. Cartridges shall accommodate Standard or Super 8 mm film in a continuous loop up to 600 ft in length, with or without optically or magnetically recorded synchronized sound track. Cartridges shall be capable of being inserted into and removed from the projector with ease by a seated student. [C1]

3.6.7 Audio Media Presentation Requirements

The optimal Carrel audio system should be capable of presenting audio-mediated instructional materials from motion picture optical sound tracks, motion picture magnetic sound tracks, and magnetic taped software, and of presenting audio output from closed-circuit student/teacher or broadcast systems through the same headset or loudspeaker terminal equipment provided for the student occupying the Carrel. The minimal audio presentation system will permit the manual switching of audio output from any of these sources without eliminating the redundancy of playback and amplification subsystems integrated into each separate type of audio reproduction equipment. For purposes of this specification, the minimal system shall be assumed: independent magnetic tape recording/ reproduction equipment, and independent student/teacher communications and broadcast equipment. Basic operational requirements for the magnetic tape reproduction equipment are presented in 3.6.3.3. [C1]

3.6.7.1 Presentation Mode. In the optimal Carrel system, the preferred mode for presenting audio-mediated instructional software would be by means of small, directional speakers capable of being positioned to "focus" audio output at the occupant's head. This system would avoid the inconvenience and encumbrance of headsets, however it would require sufficient output volume to insure intelligibility of spoken words. This requirement would contribute to the general noise level within the facility, and may be incompatible with any Carrel design except a completely enclosed cubicle, an approach that may be undersirable in terms of cost and environmental objectives. In the event this optimal method cannot be accomplished without compromising other important design and performance requirements, a two-earphone headset configuration shall be the preferred alternate for audio terminal equipment. [C1]

3.6.7.2 Headset Design and Performance Requirements. The headset configuration selected shall not exceed 10 oz. including optional boom microphone, shall be adjustable to accommodate the optimal range of the student population, and shall afford a comfortable fit with eye glasses and regardless of hair style. Earphone cushions shall be foam or liquid-filled for conformance to the head, long-term comfort, and acoustic isolation, and shall be capable of being readily removed for cleaning and replacement. Metal and nonmetallic materials of construction shall be durable, corrosion-resistant, nontoxic, and capable of being cleaned using typical solvents. Headband wiring, cordset, and quick-disconnects shall be shielded for static-free reception and transmission, fully insulated to prevent electrical shock, and locally reinforced at connections to prevent snagging, wire breakage, strain, and tampering. The compatible boom microphone assembly shall be capable of being installed on the left-hand headphone mount, and adjusted toward/away from the mouth and at least 180° in the vertical plane to assure adequate accommodation of the optimal range of student users. The headset assembly shall have a smooth frequency response characteristic as broad as that of the magnetic tape reproduction or student/teacher communication system, whichever is greater. The dynamic range shall be at least 35 db without appreciable distortion. Side tone shall be provided in the headset when the boom microphone is used for student response or intercommunications with the teacher. (Morgan, 6.4) [S1]

3.6.7.3 Headset Location and Accessibility. The headset assembly shall be positioned within the Carrel for easy access by the right-hand. The cordset shall be at least 5 ft in length to assure freedom of body positioning during monitoring and communications. [C2]

3.6.8 Magnetic Tape Playback Equipment Controls

In addition to tape speed, forward, reverse, random access, and sound synchronization control requirements specified in 3.6.3.3, equipment controls shall include loudness or gain, tone, and power on/off. The general requirements specified in 3.6.5, including 3.6.5.1 through 3.6.5.6, shall apply to magnetic tape playback equipment controls. [S1]

3.6.9 Audio Media Packaging

Instructional software to be presented using magnetic tape playback equipment shall be capable of being prepackaged in self-contained cassettes or cartridges suitable for insertion and automatic operation in the equipment installed in the Carrel. Cartridges shall accommodate magnetic tape up to 1/4 in. in width and 1-1/2 mil in thickness in a continuous loop up to 1200 ft or 1 hr playing time at 3-3/4 in. per second tape speed.

Cartridges shall be capable of being inserted into and removed from the playback equipment with ease by a seated student. [C1]

3.6.10 Student/Teacher Communications Terminal Equipment

The Carrel may incorporate voice communication terminal equipment to facilitate private conversations between the teacher or paraprofessional supervisor and the student, to permit the teacher to communicate with the individual student or with all students in a public address mode, and to permit the student to respond to audio-mediated instructional programs requiring oral participation. This system shall comprise a base or master communications station or console operable by the teacher, and input/output terminal equipment located in the Carrel and interconnected by means of cabling. Requirements for Carrel-installed terminal equipment are specified below. [C1]

3.6.10.1 Input/Output Terminal Equipment. The equipment selected for audio output of audio-mediated instructional materials shall be used for communications to the student, namely a headset assembly. Detailed requirements are presented in 3.6.7.1 through 3.6.7.3. Input of voice communications from the student shall be by means of the headset-installed boom microphone specified in 3.6.7.2 A unidirectional dynamic microphone with an effective frontal acceptance angle of ±45° may be used as an alternative input device in the event boom microphone characteristics or capabilities do not meet the specific needs of the instructional system. In special-purpose applications requiring the use of a microphone, the microphone shall be located within the plane passing through the center of the primary work space, and shall be adjustable to accommodate the optimal range of the student population seated in preferred working positions. (Morgan, 6.4) [S1]

3.6.10.2 Communications Equipment Controls. Audio output controls for the communication system including loudness or gain, tone, and on/off shall be shared with the magnetic tape playback equipment controls specified in 3.6.8, and organized into a separate subpanel in accordance with the general requirements specified in 3.6.5 through 3.6.5.6. In order to facilitate sharing of terminal equipment, a selector switch shall be provided to permit the student to select either the magnetic tape playback or the student/teacher communications audio channel. The teacher shall be able to override this control if necessary during tape playback monitoring. [S1]

3.7 LIGHTING REQUIREMENTS

Visual efficiency in studying is influenced by the type of study task being performed, by the level and quality of illumination, by color, brightness contrast and reflectance of surfaces in the study space, and by other related factors. The quantity and quality of illumination in the Carrel will be affected not only by lighting equipment and surface finishes incorporated in the Carrel itself, but also by the illumination and interior surface finishes in the facility housing the Carrel. Carrel requirements are specified in this section. Facility requirements are defined in 4.1.2. Both must be considered in order to insure the effectiveness of visual display devices installed in the Carrel, and the utility of the Carrel as a multipurpose study space. [S1]

3.7.1 Lighting Equipment

The Carrel shall be equipped with one or more installed lighting units capable of providing (1) diffused or indirect general interior illumination, and (2) direct high intensity lighting in the primary work area. The primary high-intensity study light shall be freely adjustable vertically and horizontally to permit the occupant to direct light anywhere within the Carrel, and to position it in preferred locations for reading, inspecting natural objects, viewing audio-visual instructional software, and for performing other study activities. Supplementary lumenaires shall be used to provide low-level general area illumination to reduce the brightness contrast between the primary work area and adjacent surfaces, to avoid shadows, and to provide a minimal light level for safety when facility lighting is extinguished. The supplementary lumenaires shall be located outside of the normal field of view of the student working at the desk in his preferred writing position. They shall be positioned so their image is not reflected from the surface of the rear-projection display screen. Installation requirements are specified in 3.2.6. (Morgan, 6.4) [S1]

3.7.2 Illumination

The primary study light shall provide 50 foot-candles (ft-c) of light when positioned 24 in. above the desk surface. Intensity shall be controllable from 50 to 5 ft-c in a continuous dimming mode. The color temperature of this source shall approximate the spectral distribution or color characteristics of sunlight when its intensity is adjusted to 30 ft-c ± 5 ft-c. Supplementary lighting shall not exceed 5 ft-c on a surface 3 ft away from the source. (Morgan, 6.4) [S1]

3.7.3 Controls

Carrel lighting equipment controls shall be organized into a subpanel and integrated into the common panel incorporating controls for all Carrel electrical and electronic subsystems. Controls shall be selected or designed in accordance with the requirements of 3.6.5 through 3.6.5.6. [S1]

3.7.4 Interior Surface Finishes

Surface reflectance values for interior Carrel surfaces shall conform wherever possible with the values shown in Table 2-21. Matte finishes shall be used on work surfaces in order to diffuse incident light. Large expanses of interior surface, such as enclosure walls, shall be finished with nonglossy surface treatments in nonsaturated colors. Natural wood may be used, providing the low reflectance values shown in Table 2-22 are acceptable in the locations in which the wood finishes are to be used. (Woodson, 6.5) [S2]

Table 2-21

SURFACE REFLECTANCE VALUES

Surface	Acceptable Range (%)	Optimal (%)
Enclosure walls	40 to 60	50
Work surfaces	15 to 30	15 (min.)
Installed cabinetry	25 to 35	30

Table 2-22

APPROXIMATE REFLECTANCE VALUES
FOR WOOD FINISHES

Surface Finish	Reflectance (%)
Maple	42
Satinwood	34
English Oak	17
Walnut	16
Mahogany	12

4.0 CARREL/INSTRUCTIONAL FACILITY INTERFACE REQUIREMENTS

4.1 ENVIRONMENTAL INTERFACE REQUIREMENTS

4.1.1 Temperature, Humidity and Air Movement

For purposes of this specification, the instructional facility housing the study Carrel is presumed to incorporate means of heating, cooling and circulating ventilation air, or is equipped with an air conditioning system capable of supplying fresh, uncontaminated air within the acceptable ranges of temperature, humidity, and flow rate specified below. Ventilation air shall be controllable by the teacher or facility supervisor, and shall be capable of being varied as a function of the number of people occupying the facility, outside air temperature, and amount of heat generated by lighting and instructional equipment operating in the facility. Ventilation requirements are specified in Fig. 2-17. A minimum of 5 ft^3/min per person shall be provided. For normal study activities, the temperature shall be between 68° F and 82° F, with moderate relative humidity (approximately 45%), and air movement of 15 to 25 ft/min. Since comfort is dependent upon the interrelationships between temperature, humidity, and air motion, Effective Temperature should be used as a criterion. In general, the Effective Temperature should be

A — Air Required to Provide Necessary Oxygen Content
B — Air Required to Prevent CO_2 Concentration From Rising Above 0.6 Percent
C — Air Required to Remove Objectionable Body Odors on Sedentary Adults
D — Data in Curve C increased by 50 Percent (and Projected) to Allow for Moderate Physical Activity and Odors

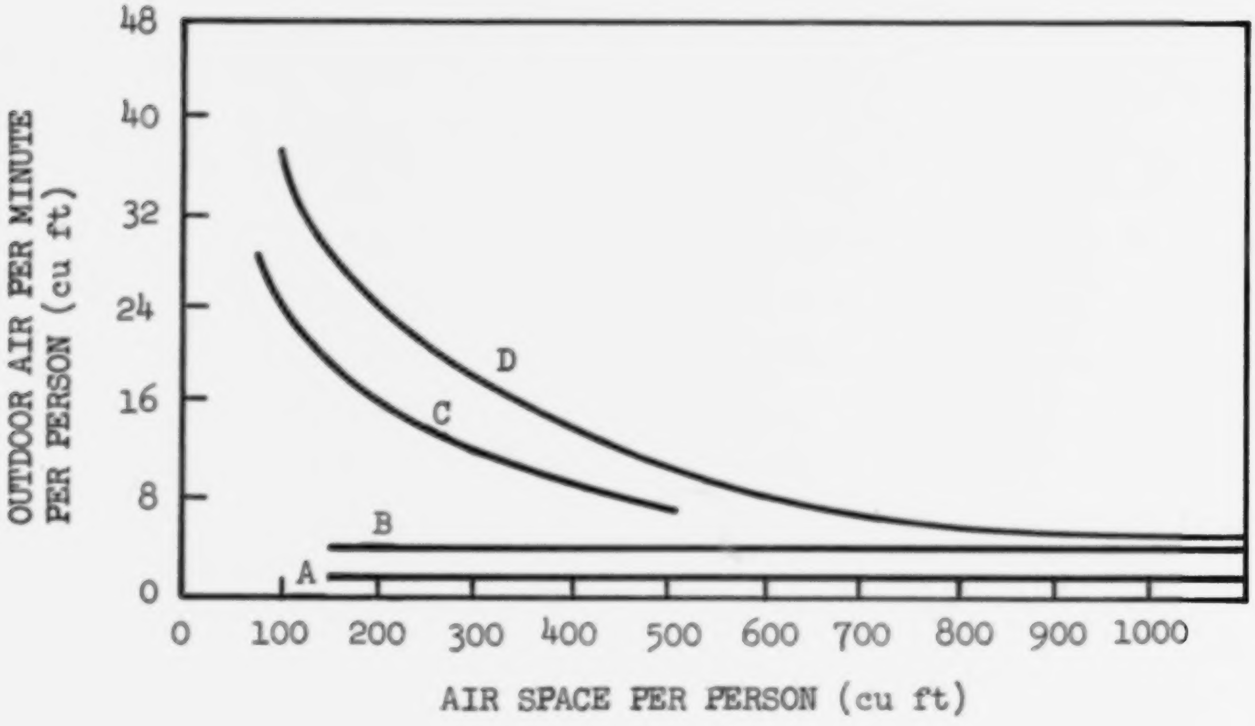


Fig. 2-17 Ventilation Requirements

maintained at approximately 72°ET ±2° in summer and 68°ET ±2° in winter. Effective Temperatures for comfort requirements are specified in Fig. 2-18. Effective Temperature in relation to dry bulb temperature and relative humidity is presented in Fig. 2-19. (MIL, 6.1) [S1]

The Carrel occupant shall not be exposed to the direct flow of ventilating air from a facility ventilator or air conditioning outlet. As specified in 1.4.8 above, heated air produced by instructional hardware and communications equipment installed in the Carrel shall not be exhausted into the interior of the Carrel. (MIL, 6.1) [S1]

4.1.2 Illumination and Interior Surface Finishes

4.1.2.1 Illumination. Of the factors contributing to visual efficiency, lighting level and color temperature are the most easily controlled. This capability must be exploited in the design of the facility lighting system in order to maximize the effectiveness of the visual display devices and lights installed in the Carrel, to facilitate Carrel maintenance and servicing, and to enhance the utility and safety of the facility itself as a multipurpose learning environment. The facility lighting system shall therefore be capable of illuminating the entire interior of the room with evenly distributed semi-indirect, indirect, or diffused light. Illumination shall be controllable in intensity from 50 ft-c down to 5 ft-c in a continuous dimming mode or in increments approximating 5 ft-c. The distribution of light shall be such that neither the light source (direct glare) nor its reflected image (specular glare) will appear in the student's visual field and particularly on the surface of such visual display devices as rear-projection screens for instructional materials. The color temperature of facility lighting shall approximate the spectral distribution of sunlight when the intensity is adjusted to 30 ± 5 ft-c. (MIL, 6.1) [S1]

4.1.2.2 Interior Surface Finishes. Surface reflectance values for interior surfaces shall conform wherever possible with the values shown in Table 2-23. Large surfaces shall be nonglossy and finished in nonsaturated colors, i.e., tints, warm grays, or earth colors. (MIL, 6.1) [S2]

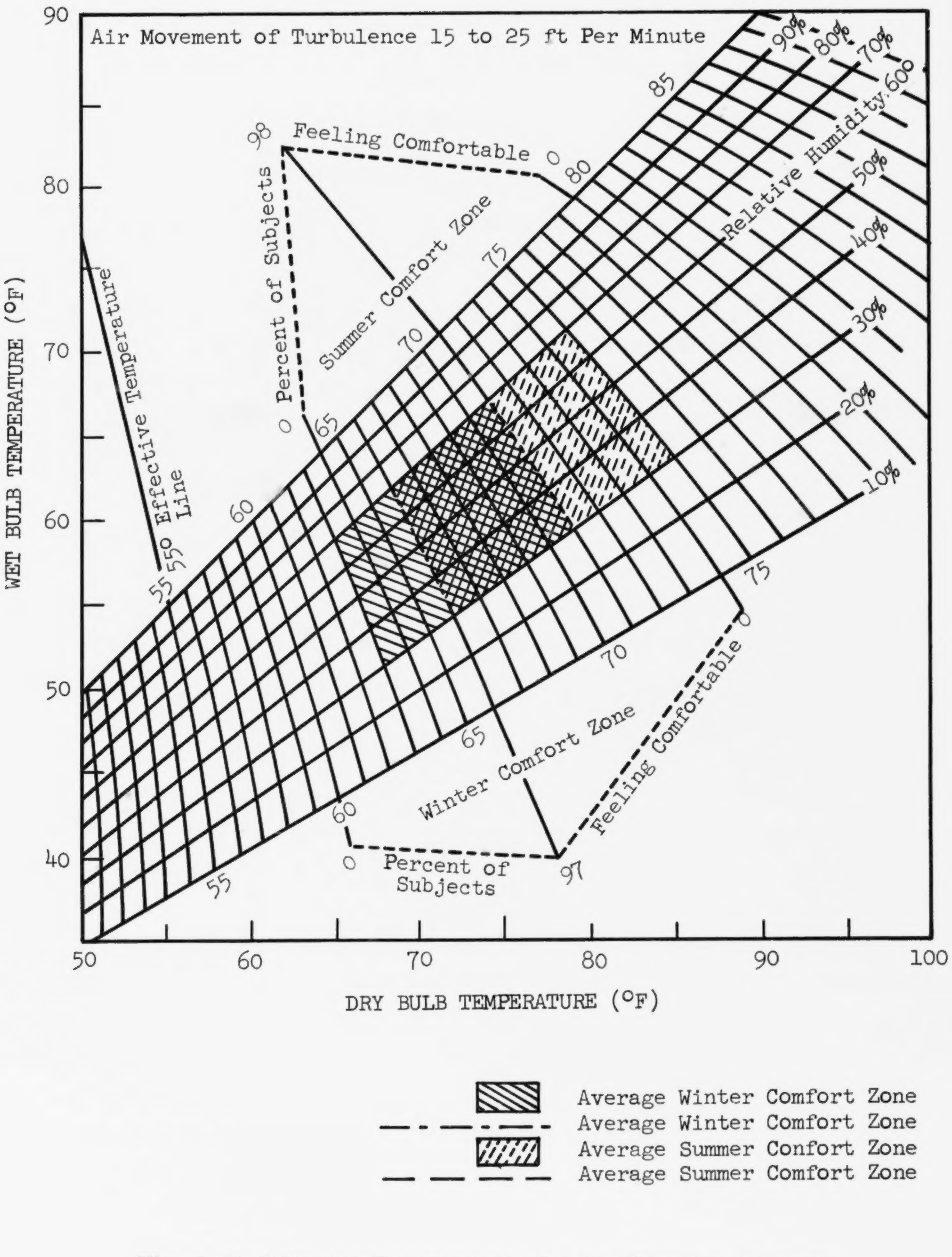


Fig. 2-18 Effective Temperatures for Comfort Requirements

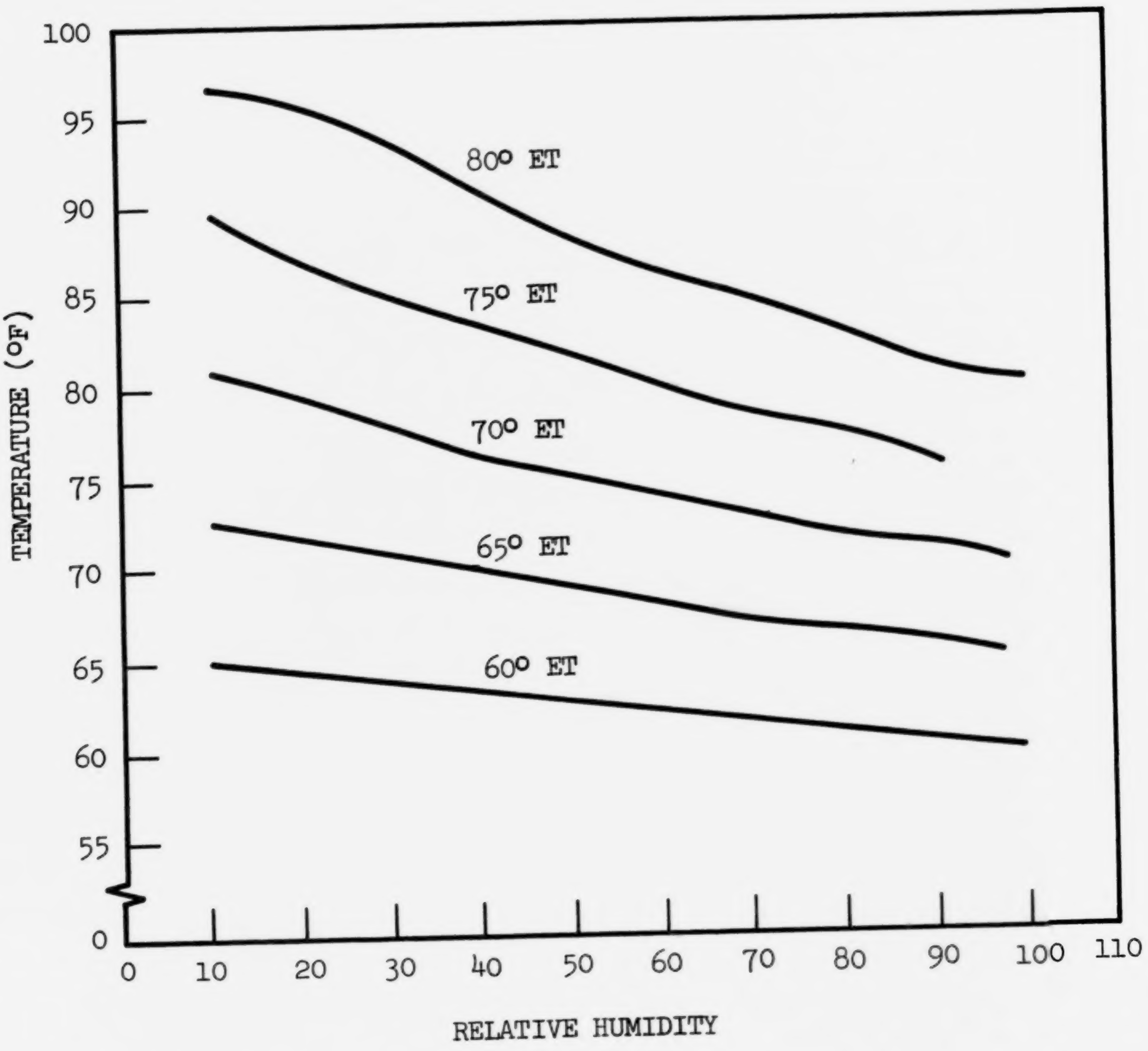


Fig. 2-19 Effective Temperature in Relation to Dry-Bulb Temperature and Relative Humidity

Table 2-23

SURFACE REFLECTANCE VALUES

Surface	Acceptable Range (%)	Optimal (%)
Walls	40 to 90	60
Ceilings	60 to 90	60
Floors	15 to 30	15 (min.)
Furnishings	25 to 35	30

4.1.3 Acoustic Noise

Noise generation and propagation within the instructional facility shall be controlled to the extent that acoustic energy will not interfere with audio-visual presentation of instructional materials, with voice communications including student-teacher participation in discussions, cause fatigue and discomfort, or in other ways degrade overall acceptance and efficiency of the Carrel and the facility as a learning environment. Facility and equipment noise shall be controlled to levels that will permit necessary voice communications. Figure 2-20 presents speech interference noise levels for various distances and voice levels. Wherever possible, the noise level within the instructional facility, when measured with all facility and Carrel equipment operating, should not exceed 45 db. The noise level generated by equipment shall not exceed the sound pressure levels shown for various octave bands on Noise Criterion (NC) Curve 45 in Fig. 2-21. Fixted facility equipment that may be difficult to silence, such as the air conditioning system, shall be isolated acoustically from the spaces occupied by Carrels. Acoustic materials with high sound-absorption coefficients shall be provided as necessary in the construction or finishing of walls, floors and ceilings to affect required noise control. Excessive noise may also be attenuated by such means as staggered layout of Carrels in multiple Carrel installations, sound baffles enclosing equipment, and thick-paned or double-paned windows in adjacent discussion or work rooms. The average room sound absorption coefficient shall be at least 0.20, but should not exceed 0.50. When an existing

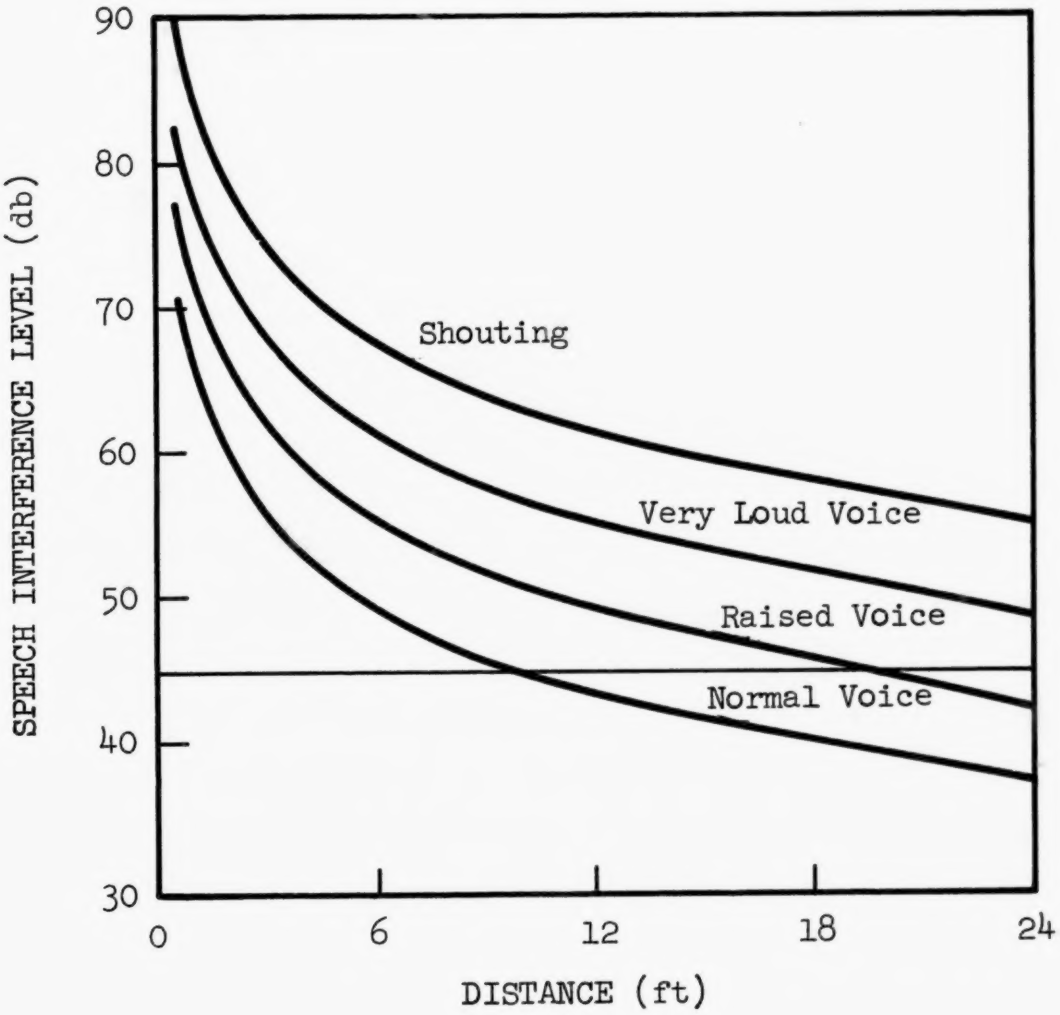


Fig. 2-20 Speech Interference Levels for Various Distances and Voice Levels

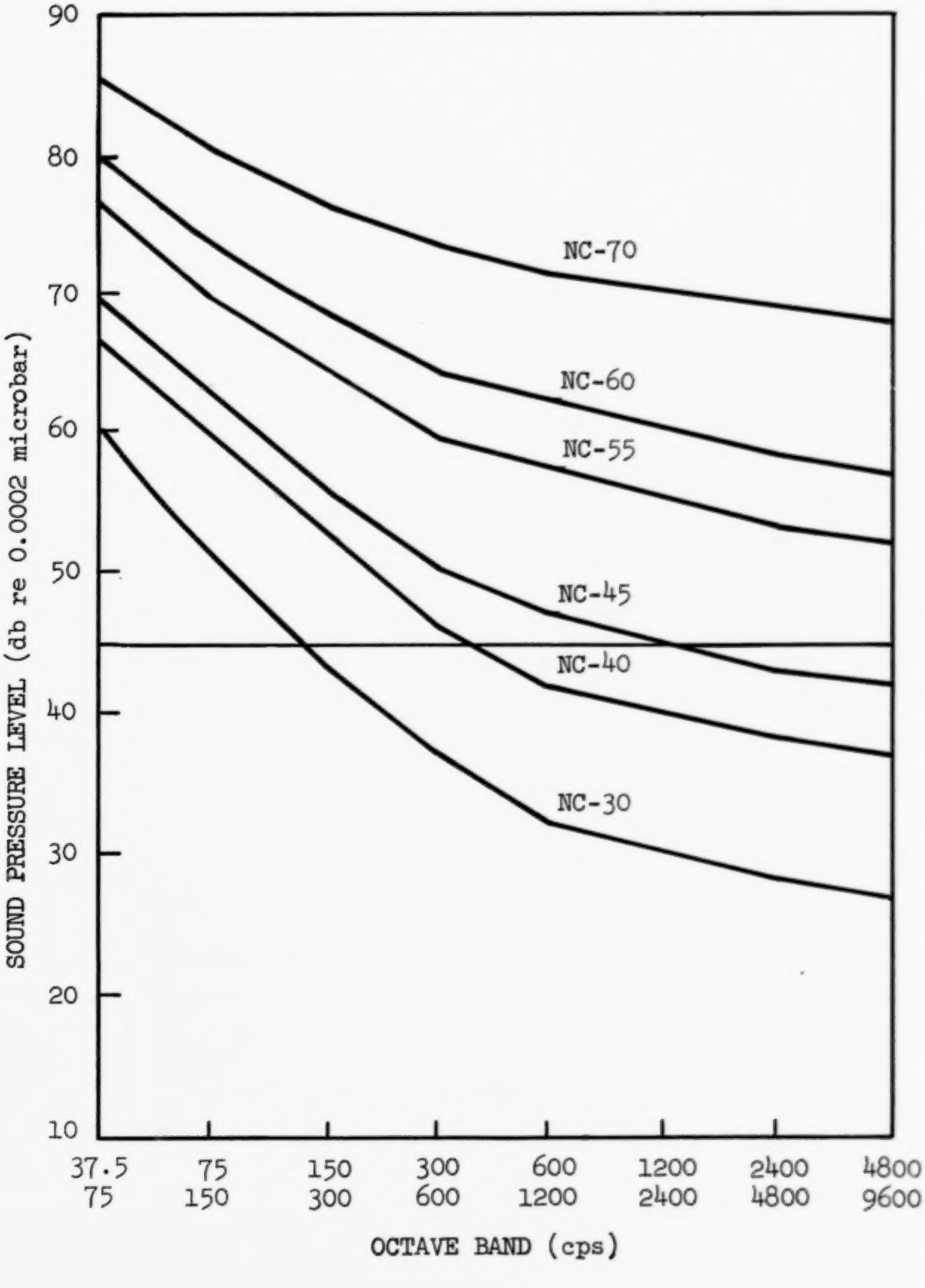


Fig. 2-21 Noise Criteria (NC) Curves for Speech Communication

instructional facility is to be improved acoustically, the total room absorption coefficient (or average coefficient) should be increased at least three times in order that the change in acoustical conditions will be definite and unmistakable. Sound absorption coefficients for materials that normally constitute the interior finish of rooms, but not including special acoustical materials, are given in Table 2-24. Reverberation time within the facility shall be reduced to the limits shown in Fig. 2-22. (MIL, 6.1) [S2]

4.1.4 Electrical/Electronic Systems Interfaces

The instructional facility shall incorporate an electrical power distribution system sized to accommodate the demands of all facility and Carrel-installed equipment operating at maximum load. Depending upon the specific needs of the facility for flexibility, the power distribution system may be permanently installed with suitable outlets for 110 vac 60 cps current and ground located at each Carrel site, or a system comprising a small number of strategically placed outlets with power to the Carrels provided by a flexible cable harness capable of being rearranged as required to accommodate varying Carrel arrangements. The electrical power interface between the Carrel and the facility power source or outlet shall consist of a single connector. As specified above, each Carrel shall be equipped with its own internal power distribution system to minimize electrical interconnections between the Carrel and the facility. Facility power services shall be suitably safeguarded to prevent damage in event of overload. Power to each facility circuit shall be capable of being turned off at a control panel within or adjacent to the facility. Electronic interconnections between Carrel communications and instructional hardware terminal equipment may be installed in a similar manner with suitable overload, grounding, and electromagnetic interference protection provisions. Wherever possible, the electronic interface between the Carrel and the facility shall consist of a single connector. Applicable state and local construction and electrical codes for new school construction shall serve as baseline requirements for the installation of electrical and electronic systems interconnections between the Carrel and the facility. [C1]

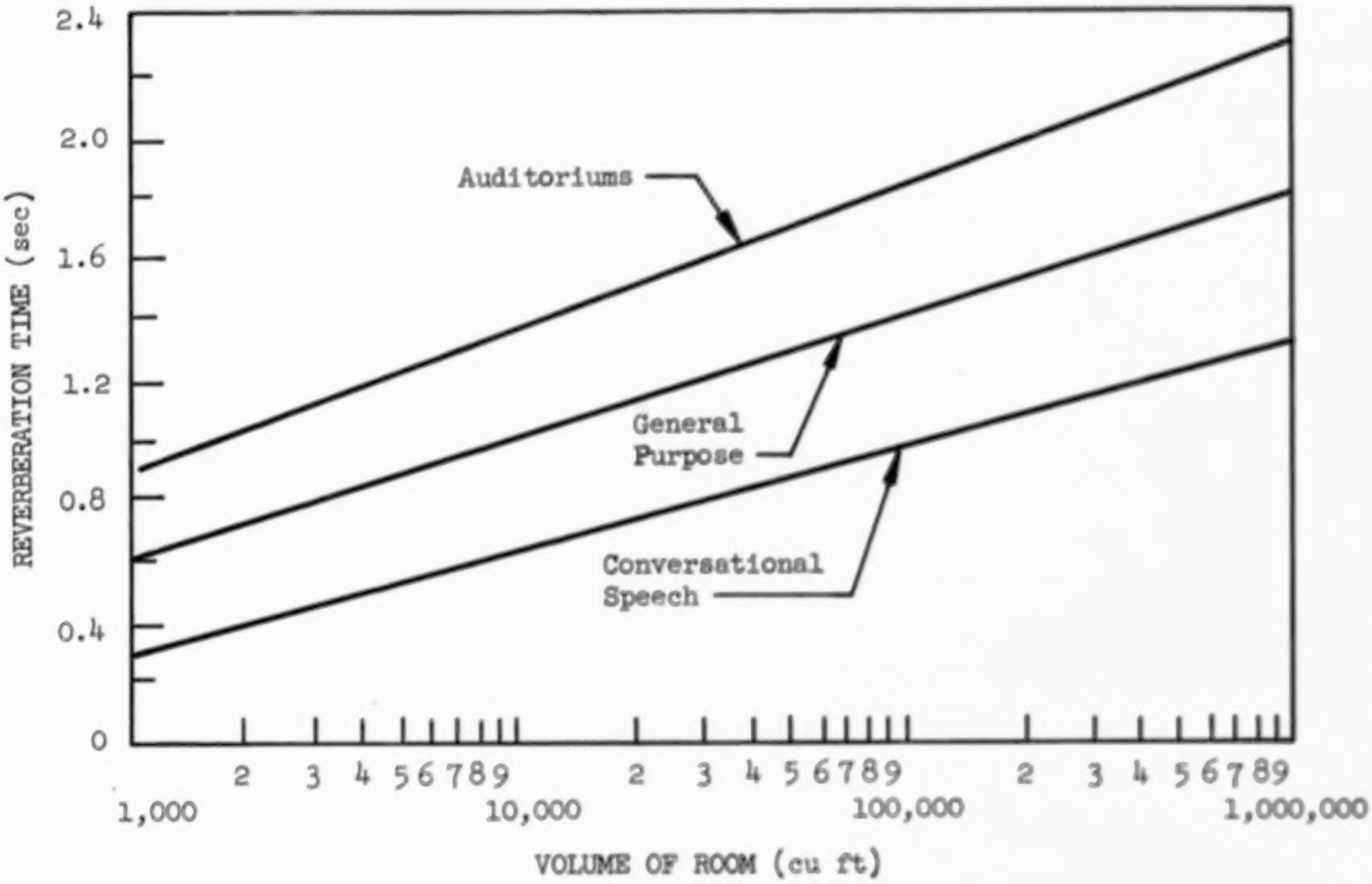


Fig. 2-22 Range of Acceptable Reverberation Time

Table 2-24

SOUND ABSORPTION COEFFICIENTS OF GENERAL BUILDING MATERIALS AND FURNISHINGS*

Materials	Coefficients					
	125 cps	250 cps	500 cps	1000 cps	2000 cps	4000 cps
Brick, unglazed	0.03	0.03	0.03	0.04	0.05	0.07
Brick, unglazed, painted	0.01	0.01	0.02	0.02	0.02	0.03
Carpet, heavy, on concrete	0.02	0.06	0.14	0.37	0.60	0.65
Same, on 40 oz hairfelt or foam rubber	0.08	0.24	0.57	0.69	0.71	0.73
Same, with impermeable latex backing on 40 oz hairfelt or foam rubber	0.08	0.27	0.39	0.34	0.48	0.63
Concrete block, coarse	0.36	0.44	0.31	0.29	0.39	0.25
Concrete block, painted	0.10	0.05	0.06	0.07	0.09	0.08
Fabrics						
Light velour, 10 oz per sq yd, hung straight in contact with wall	0.03	0.04	0.11	0.17	0.24	0.35
Medium velour, 10 oz per sq yd, draped to half area	0.07	0.31	0.49	0.75	0.70	0.60
Floors						
Concrete or terrazzo	0.01	0.01	0.015	0.02	0.02	0.02
Linoleum, asphalt, rubber or cork tile on concrete	0.02	0.03	0.03	0.03	0.03	0.02
Wood	0.15	0.11	0.10	0.07	0.06	0.07
Wood parquet in asphalt on concrete	0.04	0.04	0.07	0.06	0.06	0.07
Glass						
Large panes of heavy plate glass	0.18	0.06	0.04	0.03	0.02	0.02
Ordinary window glass	0.35	0.25	0.18	0.12	0.07	0.04

Table 2-24 (Cont.)

Materials	Coefficients					
	125 cps	250 cps	500 cps	1000 cps	2000 cps	4000 cps
Gypsum board, 1/2 in. nailed to 2 × 4's 16 in. o.c.	0.29	0.10	0.05	0.04	0.07	0.09
Marble or glazed tile	0.01	0.01	0.01	0.01	0.02	0.02
Openings						
Stage, depending on furnishings			0.25	0.75		
Deep balcony, upholstered seats			0.50	1.00		
Grills, ventilating			0.15	0.50		
Plaster, gypsum or lime, smooth finish on tile or brick	0.013	0.015	0.02	0.03	0.04	0.05
Plaster, gypsum or lime, rough finish on lath	0.02	0.03	0.04	0.05	0.04	0.03
Same, with smooth finish	0.02	0.02	0.03	0.04	0.04	0.03
Plywood paneling, 3/8 in. thick	0.28	0.22	0.17	0.09	0.10	0.11
Water surface, as in a swimming pool	0.008	0.008	0.013	0.015	0.020	0.025
Air, sabins per 1000 cu ft					2.3	7.2

*Complete tables of coefficients of the various materials that normally constitute the the interior finish of rooms may be found in the various books on architectural acoustics. The aboee short list will be useful in making simple calculations of the reverberation in rooms.

4.1.5 Carrel Arrangement

The arrangement of the Carrel assemblies in a multiple-Carrel installation shall be based upon the following factors:

a. The objectives of the instructional system
b. The size and proportions of the facility available
c. Size of student class to be accommodated
d. Access to fire exits and safety equipment
e. The requirement for visual monitoring
f. Ventilation requirements
g. Illumination requirements
h. Noise control considerations
i. Accessibility for maintenance and servicing

With these constraints and the general strategy of facility design for maximum cost-effectiveness, the overall objectives of interior layout should be to develop an optimal learning environment conducive to individualized science study and to the achievement of specified terminal behaviors in science, and to general acceptance by students and Reference and Support System personnel based on the type and degree of their participation in the operation and servicing of the facility. [C2]

5.0 CARREL/SUPPORT SYSTEM INTERFACES

In order for the Carrel to serve its primary functions within the instructional system, it must be capable of being installed, serviced and maintained by Support System maintenance personnel and equipment. In addition, audio-visual mediated instructional software, and the personnel responsible for developing these materials, must find the design and performance capabilities selected for Carrel instructional hardware compatible with their products. The principle interdependent relationships or interfaces between the Carrel and the Support System include accessibility for the Carrel and equipment installation, servicing and maintenance, and factors relating to design for maintainability.

5.1 CARREL SUBSYSTEM ACCESSIBILITY

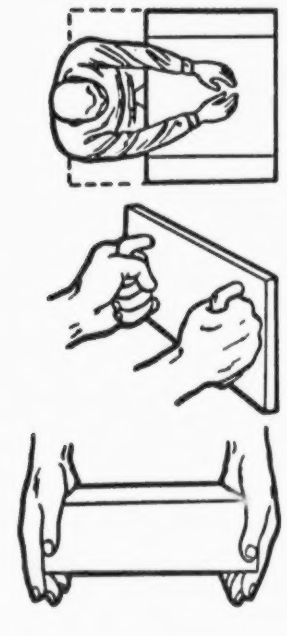
All major Carrel subsystems and components shall be designed so that the entire Carrel assembly can be erected from within the space to be occupied by the Carrel itself. It should not be necessary to obtain access to the outside of the Carrel enclosure, or to the rear surface of the rear wall, to assemble the Carrel or to gain access to equipment, cabling, or other components. All major Carrel subsystems and components shall be accessible from within the Carrel enclosure for installation and performance of periodic maintenance, servicing, replacement, or repair tasks. All installed equipment shall be positioned or located to minimize the time required and the difficulty of gaining access. Equipment requiring frequent access shall not be placed beneath or behind structural members or other components requiring less frequent access for servicing or replacement. The physical placement of equipment shall be such that high-failure items will be readily accessible for replacement without removing nonfailed components. [C1]

5.1.1 Access Openings

Access openings provided for installing, adjusting, servicing and removing components shall be sufficiently large to permit these required operations and provide an adequate view of the equipment or components being manipulated. Dimensions of access openings shall be no less than those shown in Fig. 2-23. All access covers or doors that are not completely removable shall be self-supporting in the open position. Fasteners used to retain access doors or covers should be of tamper-proof design or require a special hand tool for removal and replacement. (MIL, 6.1)[S1]

5.1.2 Access Labeling

If information or instructions relating to a component must be readily available during servicing, they should be placed on the inside of the access cover or door and oriented so they can be read conveniently under normal facility lighting conditions when the door



MINIMAL TWO-HAND ACCESS OPENINGS:

Reaching with both hands to depth of 6 to 25 inches:

Light clothing: 5" high by 8" or 3/4 depth of reach *

Reaching full arm's length (to shoulders) with both arms:

Width = 19-1/2 inches, height = 4 inches

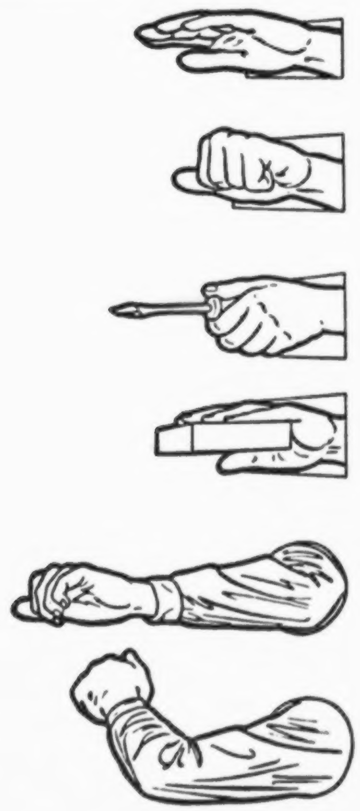
Inserting box grasped by handles on the front:

1/2" clearance around box, assuming adequate clearance around handles

Inserting box with hands on the sides:

Light clothing: Width: Box plus 4-1/2"
Height: 5" or 1/2" around box *

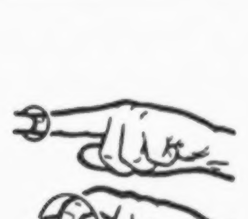
NOTE: If hands will curl around bottom of box, allow an additional 1-1/2" in height for light clothing.



MINIMAL ONE-HAND ACCESS OPENINGS:

	Width	Height
Empty hand to wrist:		
Bare hand, rolled:	3.75" sq. or dia.	
Bare hand, flat:	2.25"	× 4.0" or 4.0" dia.
Glove	4.0"	× 6.0" or 6.0" dia.
Clenched hand, to wrist:		
Bare hand:	3.5"	× 5.0" or 5.0" dia.
Glove	4.5"	× 6.0" or 6.0" dia.
Hand plus 1" dia. object, to wrist:		
Bare hand:	3.75" sq. or dia.	
Glove	6.0" sq. or dia.	
Hand plus object over 1" in dia. to wrist:		
Bare hand:	1.75" clearance around object	
Glove	2.5" clearance around object	
Arm to elbow:		
Light clothing:	4.0"	× 4.5" or 4.5" dia.
Arm to shoulder:		
Light clothing:	5.0" sq. or dia.	

MINIMAL FINGER ACCESS TO FIRST JOINT:



Push button access: Bare hand: 1.25" dia.

Two-finger twist access:
Bare hand: 2.0" dia.

* Whichever is larger.

Fig. 2-23 Access Dimensions

is opened. Labels for hazardous components, such as high voltage or high temperature components, shall be placed on or adjacent to the hazardous item, or on the exterior of the access cover for that item. Label requirements are defined in 3. 6. 5. 6. (MIL, 6. 1)[S]

5. 2 INTERCHANGEABILITY OF PARTS

In addition to the requirements of 2. 2, the Carrel shall be designed to incorporate standard parts, fasteners, and other common components to the maximum extent feasible. A high degree of interchangeability and replaceability of like or similar items shall be provided. The need for special tools, test and support equipment to service, adjust, maintain and repair Carrel subsystems and components shall be minimized. Items serving the same function in different Carrels of identical design shall be interchangeable. (MIL, 6. 1)[S2]

5. 3 DESIGN FOR EFFICIENT HANDLING

With the exception of major Carrel subassemblies defined in 2. 3, equipment shall be modularized so that the weight of each removable component does not exceed 45 pounds. When modules must exceed 45 pounds, provision must be made for lifting by two men. All modules weighing more than 45 pounds shall be labeled as to their weight and approximate center of gravity. Carrel subsystems or components intended to be removed for servicing and maintenance or replacement shall be provided with suitable means for grasping, handling and carrying. At least 2 in. of clearance shall be provided between the component to be removed and any adjacent component or structural surface. Care shall be taken to insure that removal components cannot be replaced improperly or out of alignment. Captive fasteners shall be used to mount or align components in situations where dropping such items might cause damage to equipment or create a difficult or hazardous removal problem. (MIL, 6. 1)[S1]

5.4 CABLING AND CONNECTORS

Electrical or electronic cabling required to interconnect the Carrel with facility services and with the teacher's communications equipment shall be readily accessible for connection from within the Carrel. Cable or wiring internal to the Carrel shall be permanently mounted by means of cable or wire clamps and concealed from view to prevent tampering and accidential damage. Cables and wiring shall be routed in such a way that they will not be pinched by access doors or equipment, or bent or twisted repeatedly. If it is necessary to route wiring or cables through holes in the enclosure or in internal structural members, the conductors shall be protected from chafing or wear by grommets mounted in the holes. Wherever possible, quick-disconnect-type plugs or connectors shall be used. Plugs or connectors and their receptacles shall be provided with aligning pins or guides to prevent improper insertion and misalignment. Plugs or connectors shall be selected so that it is impossible to mate the wrong connector/receptacle assemblies. When two or more connectors must be mounted side-by-side, they shall be spaced far enough apart that they can be grasped firmly for connecting and disconnecting. Spacing shall not be less than 2 in. Mating connectors and receptacles shall be coded by size or color or both means. Receptacles shall be labeled to identify their function. (MIL, 6.1)[S2]

5.5 FUSE REQUIREMENTS

The main power circuit installed in the Carrel shall be equipped with a fuse or circuit breaker to prevent overloading. Fuses shall be readily accessible for removal and replacement. It shall not be necessary to remove any other components in order to gain access to fuses or circuit breakers. Spare fuse holders shall be provided adjacent to the fuse installation. [C1]

6.0 REFERENCES

6.1 MIL-STD-803A-2, Human Engineering Design Criteria for Aerospace Systems and Equipment; Part II, Aerospace System Facilities and Facility Equipment, United States Air Force, 1 December 1964.

6.2 Damon, A., H.W. Stoudt, and R.A. McFarland, The Human Body In Equipment Design, Cambridge: Harvard University Press, 1966.

6.3 Martin, W.E. The Functional Body Measurements of School Age Children; A Handbook for Manufacturers, Design Engineers, Architects, and School Officials for Use in Planning School Furniture, Equipment and Buildings, Chicago: National School Service Institute, 1954.

6.4 Morgan, C.T., A. Chapanis, J.S. Cook, and M.W. Lund, Human Engineering Guide to Equipment Design, New York: McGraw-Hill Book Company, 1963.

6.5 Woodson, W.E. and D.W. Conover, Human Engineering Guide for Equipment Designers, Berkeley: University of California Press, 1964.

PART III

DISCUSSION ROOM DESIGN AND PERFORMANCE REQUIREMENTS

1.0 INTRODUCTION

Within the CLSP science learning system concept, the small group discussion mode of instruction is intended to facilitate free interchange of ideas and concepts relating to specific content areas and experiences developed in other mode/media environments. The small group discussion serves as a vehicle for transferring or generalizing what has already been learned, and for sharing the collective observations, judgments, and values of the student participants arising out of their exposure to common stimulus materials. The teacher's role in this setting is essentially non-authoritarian, involving service to the discussants as a stimulator of interaction and interchange, as an arbiter of disputes, and as a source of information when questions of content arise. The design of the Discussion Room environment and furnishings must not compromise this role by establishing a specific workspace identifiable as the teacher's, or by differentiating one position or location in the room to which the attention of all others is focussed. Rather, an effective one-to-one encounter between the teacher and any student discussant must be fostered by consideration of design factors that will enable this relationship to emerge naturally as a function of the design and general arrangement of the environment and its furnishings.

1.1 SCOPE OF THE SPECIFICATION

This specification establishes design and performance requirements for a small group Discussion Room and for the functional interfaces between the Discussion Room and other elements of the instructional system for secondary science education. Requirements defined below are applicable to the development of a Discussion Room design for System C, employing audio-visual presentation equipment defined for System B. (CLSP, 6.1)*

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*An author's name (or the abbreviation of a corporate author) and serial number appearing within parentheses identify references listed in Section 6.0 at the end of Part III.

1.2 PURPOSE

The purpose of the Discussion Room is to provide a learning environment conducive to the group exploration of secondary science topics. The Discussion Room is a completely enclosed study area incorporated into the instructional facility.

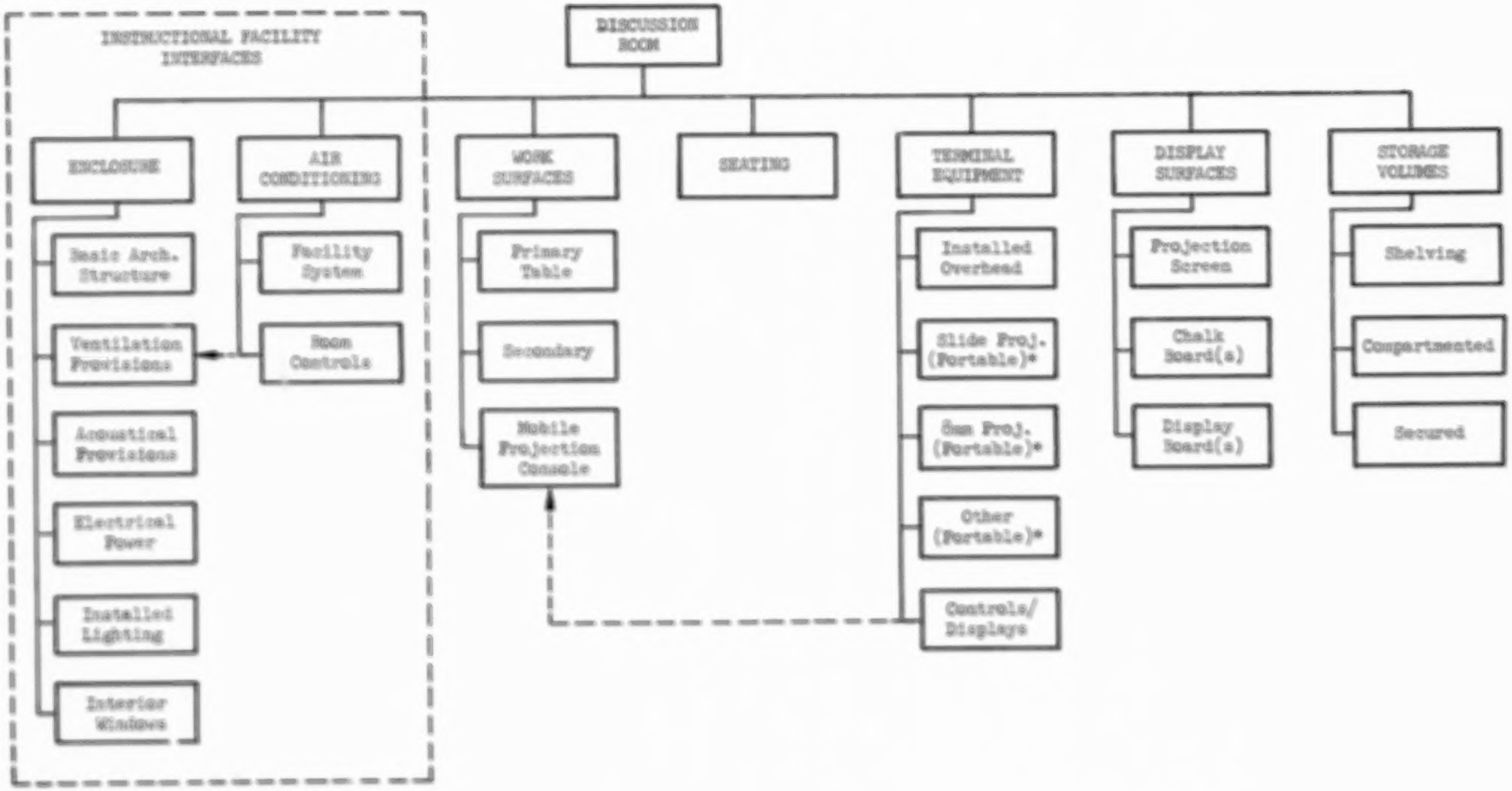
1.3 FUNCTIONS OF THE DISCUSSION ROOM

The primary function of the Discussion Room is to provide a study environment capable of accommodating one teacher and up to nine students, and the instructional materials, audio-visual presentation hardware, teaching aids and furnishings necessary to conduct small group discussions of selected topics in an instructional package.

Secondary functions may include individualized student-teacher conferences, student testing and evaluation of the attainment of instructional objectives, in-service training of professional and para-professional personnel, assessment of audio-visual materials, and instructional system development. Design and performance trade-offs involving primary and secondary functions shall be reconciled wherever possible in favor of the primary function of the Discussion Room.

1.4 DISCUSSION ROOM SUBSYSTEMS AND COMPONENTS

The Discussion Room shall be designed as an integral part of the instructional facility in accordance with applicable architectural, structural, electrical, air conditioning, safety, and other codes for new school construction. The basic facility services and utilities designed in accordance with statutory requirements shall be augmented as specified below to provide the additional capability required for a fully-integrated Discussion Room. Figure 3-1 identifies the structural and functional subsystems of the Discussion Room, and the major components comprising each subsystem. These subsystems and components are defined in the following paragraphs.


DISCUSSION ROOM
INSTRUCTIONAL FACILITY INTERFACES
ENCLOSURE
Basic Arch. Structure
Ventilation Provisions
Acoustical Provisions
Electrical Power
Installed Lighting
Interior Windows
AIR CONDITIONING
Facility System
Room Controls
WORK SURFACES
Primary Table
Secondary
Mobile Projection Console
SEATING
TERMINAL EQUIPMENT
Installed Overhead
Slide Proj. (Portable)*
8mm Proj. (Portable)*
Other (Portable)*
Controls/ Displays
DISPLAY SURFACES
Projection Screen
Chalk Board(s)
Display Board(s)
STORAGE VOLUMES
Shelving
Compartmented
Secured

*System B Type Equipment

Fig. 3-1 Discussion Room Subsystems and Components

1.4.1 Enclosure and Instructional Facility Interfaces

In order for the Discussion Room to serve its primary function effectively and economically within any existing or new secondary science instructional facility, certain functional requirements of the Discussion Room must be satisfied by facility subsystems. Conversely, the room must be designed to permit its construction in any given facility in a manner that will make the most effective use of available space within the facility. These interdependent relationships or interfaces between the Discussion Room and the facility include enclosure structure, environmental factors, electrical power, interconnections between the facility and the teacher's mediation and communication console, installation requirements, and other considerations. [C1]*

The Discussion Room enclosure may comprise permanently-installed facility walls or, alternatively, folding walls, or a combination of both if secondary functions identified for the room require that the enclosure be capable of being fully opened for unrestricted access or use of the space. In general, however, folding walls will not provide the degree of acoustical noise attenuation required, adequate surface for software displays, or the capability to integrate interior windows to provide visibility into and out of the Discussion Room. Permanent walls shall provide vertical surfaces for displaying or exhibiting reference materials, mounting chalk boards, and mounting a projection screen for visually-mediated study materials. The enclosure shall provide inlets and returns for room ventilation or air conditioning, electrical power for portable audio-visual presentation terminal equipment, and other purposes, and lighting equipment for general area illumination. [C1]

The facility shall incorporate a lighting subsystem capable of providing general area illumination ranging in intensity from that required for library activities to OFF. The control for varying facility illumination level shall be in a permanent wall of the Discussion Room. Floor, wall, and ceiling surfaces shall be equipped with a suitable mix of acoustic noise attenuation materials in order to maintain an acceptable noise level when the Discussion Room is occupied by 10 people and the occupants are operating audio-visual display equipment. Facility air conditioning shall be capable of providing filtered air within the preferred range of temperatures, humidities, and flow rates for instructional facilities. This subsystem shall be capable of rejecting the incremental heat load imposed by operation of audio-visual display equipment and 10 adult occupants. [C1]

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*The code appearing within brackets refers to ratings of design criteria statements that are identified in Section 2.0, Table 3-1. For example, [C1] indicates an excellent, common sense requirement.

The Discussion Room shall be equipped with an electrical power distribution subsystem sized to accommodate the demands of all equipment operating at maximum load. Depending upon the specific needs of the facility for flexibility, the power distribution system may be permanently installed with suitable outlets located around the perimeter, plus a flexible power distribution harness capable of being rearranged as required to accommodate equipment operations in various temporary arrangements. Electrical and electronic interfaces between instructional hardware and communications terminal equipment may be installed in a similar manner with suitable electromagnetic interference suppression provisions and overload protection. [C1]

Applicable construction, electrical, air conditioning, and other codes for new school construction shall serve as baseline requirements. The basic facility subsystems designed in accordance with these requirements must be augmented to provide the additional capability required for an efficient Discussion Room configuration. [S1]

1.4.2 Work Surfaces

The Discussion Room shall be equipped with a single conference table, or two or more smaller tables of identical design that may be assembled into an arrangement suitable for conducting small group discussions, the examination of natural objects, reading and writing activities, and other tasks defined above in 1.3. Secondary horizontal work surfaces may be provided in the form of shelving, wall-hung compartments, etc. A mobile console shall be equipped with an integral overhead projector, random-access 35 mm slide projector control unit, electrical power outlets for portable slide projection, motion picture projection, and magnetic tape reproduction equipment, and an integrated control/display console for the teacher. [C1]

1.4.3 Seating

The Discussion Room shall be equipped with chairs specifically selected or designed to accommodate the anthropometric dimensions of the using population. The chair shall permit the student to seat himself in those positions in which he prefers to read, write, monitor audio-visual presentations, and participate in small group discussions, and shall provide body support for periods up to two (2) hours duration without discomfort or fatigue. The seat shall be free-standing, shall be castered to permit free movement, and shall be capable of being readily removed from the Discussion Room. [S1]

1.4.4 Instructional Hardware Terminal Equipment

The Discussion Room shall be designed to facilitate the presentation of audio-visual instructional software including still and motion picture imagery with and without synchronized sound, video imagery with and without sound, magnetic sound recordings, opaque and transparent display materials, and other media. The teacher's mobile projection console shall be designed to accommodate portable, self-contained projection and magnetic playback equipment, and to facilitate operation and control from the seated position. Audio output devices for this equipment shall comprise an installed speaker system capable of operation with all equipment. [C1]

1.4.5 Display Surfaces

Interior walls of the Discussion Room shall incorporate a mix of surface finishing materials suitable for use as chalk boards, display surfaces for exhibiting reference data such as maps, illustrations, charts, and other software, and acoustical noise attenuation materials. At least one, and preferably two, projection screens shall be provided for projecting transparencies, slides, and films. Twin screens will permit simultaneous projection of related displays in any combination of media. Screens shall be permanently installed and stowable to prevent damage when they are not in use. Screens shall be readily accessible for deployment and stowage by students as well as the teacher or para-professional supervisor. [C1]

1.4.6 Storage Volumes

Depending upon the specific needs of the science instructional program, and the small group discussion mode of instruction, the Discussion Room may incorporate built-in shelving and compartmented storage volumes for instructional software and hardware, or furniture that accomplishes this function. Installed or portable storage equipment shall be designed for convenient use by the student and teacher using population, and shall be so located as to avoid interference with the normal pattern of traffic, the conduct of small group discussions, and other activities defined in 1.4. [C1]

1.5 DISCUSSION ROOM/SUPPORT SYSTEM INTERFACES

The Discussion Room shall be designed to facilitate maintenance and servicing by personnel comprising the Support System. [C1]

2.0 GENERAL REQUIREMENTS

2.1 SIMPLICITY OF DESIGN

Simplicity shall be a major objective of Discussion Room design, structural and functional components of the room shall be of the simplest design and construction that will fulfill instructional system requirements and expected school service conditions. Tradeoffs among alternative approaches to a design solution shall favor the least complicated approach wherever possible. Design or selection tradeoffs favoring simplicity will generally increase reliability and safety, assure ease of operation and maintenance, and increase the cost-effectiveness of the final Discussion Room design. [C1]

Ratings for design criteria are presented in Table 3-1. The ratings provide an assessment of the evidence supporting the criteria.

Table 3-1

DESIGN CRITERIA RATING SCALES

Category/Rating	Definition
S = Supported	These criteria are supported by empirical studies and provide the most concrete bases for design requirements.
C = Common Sense	These criteria often reflect long-standing usage and acceptance and seem appropriate logically or instinctively. They emphasize the obvious and tend to reduce controversy over points that lack empirical support.
A = Arbitrary	These are criteria for which there is no empirical or logical support. Their virtue is that of providing standardization which, in turn, contributes to reliability and cost-effectiveness.
1 = Excellent	Excellent research support or unquestionable logic, or experience indicates that this is necessary.
2 = Good	Good research support or good logic, or experience indicates that this is good; deviation should be strongly justified.
3 = Fair	Incomplete or questionable research support or questionable logic, or experience indicates some success; deviation permitted with justification.

2.2 STANDARDIZATION

Discussion Room subsystems, components, controls, displays, labels, and general arrangement shall be uniform for all equipment developed in accordance with this specification. When two or more Discussion Rooms are installed in the same instructional facility, their subsystems and components shall be interchangeable wherever possible to permit the use of common servicing and maintenance personnel and equipment, to permit the teacher to follow the same procedures in operating equipment common to all Discussion Rooms, and to reduce the cost of purchasing, replacing, and repairing unserviceable equipment. [C2]

2.3 SPACE LIMITATIONS

The physical size and proportions of the Discussion Room assembly shall be dictated by the workspace requirements of the intended occupants and maintenance personnel. It shall be no larger than is necessary to satisfy the functional requirements of this specification in order to make the most effective use of space in existing or new school construction. [C2]

2.4 VISUAL MONITORING

The interior general arrangement of the Discussion Room shall be designed to permit the teacher or para-professional supervisor to monitor student activities and to interact with all students with equal ease. One or more windows shall be installed in the interior walls of the Discussion Room enclosure to permit the teacher to monitor activities taking place within or outside the Discussion Room. [C1]

2.5 SAFETY

Consideration shall be given to structural, mechanical, and electrical safety factors, and to the elimination of design features that could result in injury to personnel using or maintaining the Discussion Room or in damage to structure or equipment. When adherence to design and performance requirements established in this specification may lead to the creation of a potential hazard to personnel or equipment, the safety consideration shall receive the heaviest weighting. Whenever cost-effectiveness analysis indicates that a design or performance requirement may be satisfied by commercially-available equipment, the selection process shall include consideration of personnel and equipment safety features. Equipment having modes of failure that could result in damage to the equipment or injury to the user should be avoided wherever possible. [C1]

2.6 SANITATION

Consideration shall be given to the continuing requirement for the maintenance of Discussion Room cleanliness in its intended multi-usage school environment. Selection of materials of construction, surface finishes, acoustical materials, terminal equipment, and other components shall include consideration for ease of cleaning and maintenance of adequate sanitary conditions throughout the useful life of the facility and equipment. [C1]

3.0 DISCUSSION ROOM DESIGN AND PERFORMANCE REQUIREMENTS

3.1 ANTHROPOMETRIC WORKSPACE DESIGN REQUIREMENTS

The Discussion Room enclosure, furnishings, and installed equipment shall be designed to accommodate the student, professional, and support system personnel whowill program, support and maintain its operation in the instructional facility. Anthropometric design requirements for the using populations are presented in Sections 3.1.1 through 3.1.11 and Tables 3 through 15 of (CLSP, 6.1), and will not be duplicated in this document. [S1]

3.2 ENCLOSURE DESIGN REQUIREMENTS

3.2.1 Structural Requirements

The Discussion Room enclosure may comprise permanently-installed facility walls, folding walls, or a combination of both types depending upon requirements for the enclosed space to serve secondary functions in addition to those defined in 1.3 above. In developing facility layouts incorporating one or more Discussion Rooms, tradeoffs among exterior masonry walls, interior wood or metal walls, and folding wood, metal or fabric walls, must consider the location and routing of such services as ventilating air and air conditioning, electrical power, and communications, and the requirements for doors, interior windows to permit observation from within and outside the room, and acoustical requirements. In general, folding walls will not permit incorporation of air conditioning ducts and vents, power and communications wiring, doors, or interior observation windows. Regardless of construction, enclosure walls shall extend from floor to ceiling. [A2]

3.2.2 Size

The enclosure shall be sized to accommodate the internal workspace envelope defined by seating work surface, storage volume, and instructional hardware accessibility requirements. It shall be no larger than necessary in terms of floor space consumed to satisfy the functional requirements of the student, Reference, and Support System populations. Figure 3-2 illustrates some of the many possible shapes and arrangements for Discussion Rooms. Figure 3-3 illustrates the clearance dimensions necessary to facilitate freedom of movement and to optimize the field of view for viewing wall-mounted displays, chalkboards, and visual materials projected on a screen. (Morgan, 6.2) [S2]

3.2.3 Access

At least one doorway shall be provided in the enclosure for entrance and egress. Doorways should be located in a corner of the room to provide maximum wall space for displays and chalkboards, and to minimize the clearances needed for entering and leaving the room. The opening shall be sufficiently wide to accommodate the largest adult in the Reference and Support System population carrying the largest component of portable equipment capable of being used in the Discussion Room. Minimal Opening Width: 36 in. (Morgan, 6.2). [S2]

3.2.4 Surface Finishing

All exposed surfaces of enclosure walls shall be finished with a suitable protective surface finish capable of meeting the school service conditions anticipated and sanitation requirements specified in 2.6 above. [S2]

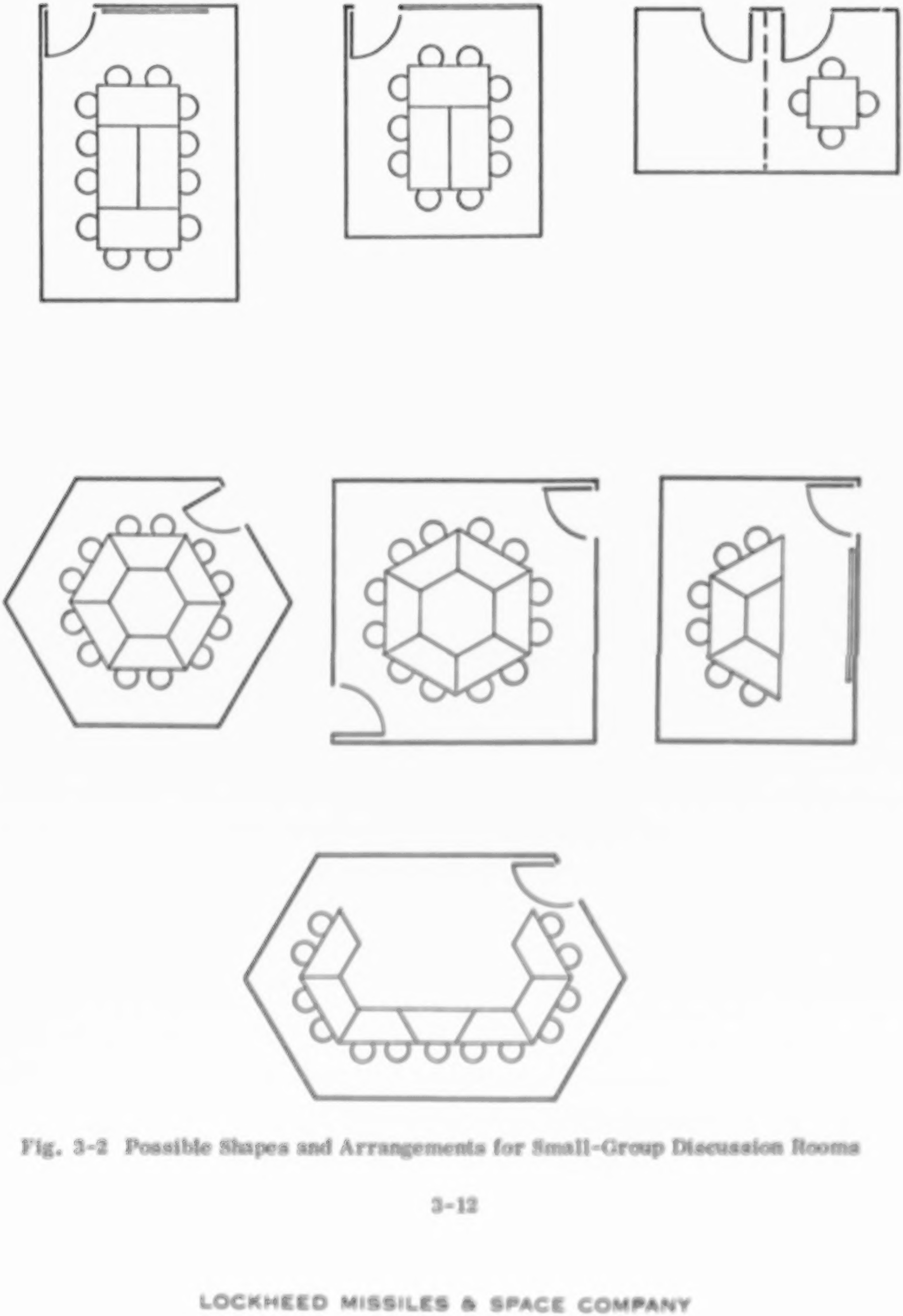

Fig. 3-2 Possible Shapes and Arrangements for Small-Group Discussion Rooms

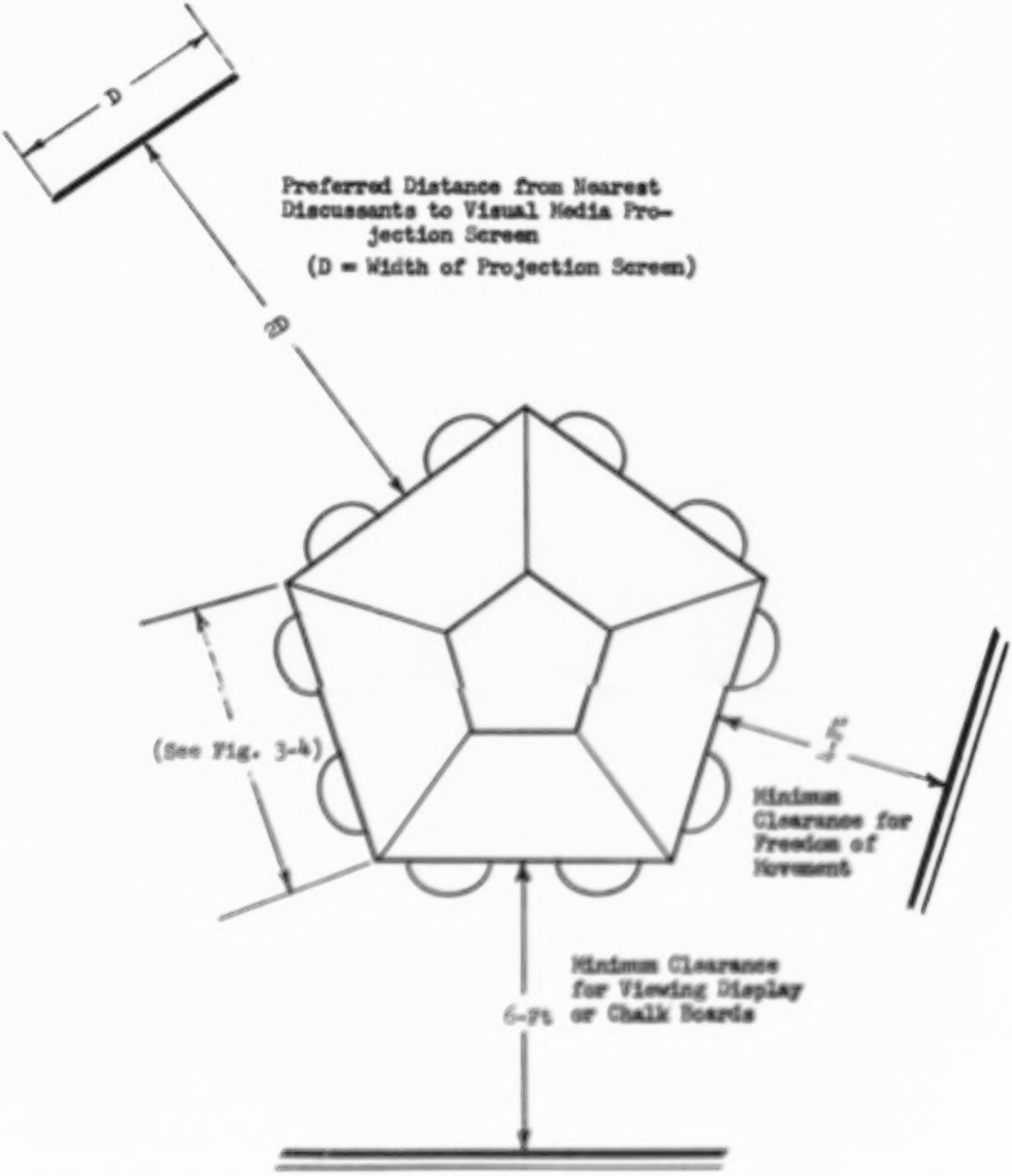
D
Preferred Distance from Nearest Discussants to Visual Media Projection Screen
(D = Width of Projection Screen)
2D
(See Fig. 3-4)
4-Ft
Minimum Clearance for Freedom of Movement
6-Ft
Minimum Clearance for Viewing Display or Chalk Boards

Fig. 3-3 Preferred Clearance Dimensions for Room Layouts

3.2.4.1 Noise Attenuation. Portions of exposed interior walls and ceiling shall be surfaced with noise attenuating material in order to minimize propagation or reflection of sounds produced within the Discussion Room by small group discussion activities and by audio-visual equipment, and to attenuate noise produced outside the room that might interfere with study activities underway within the Discussion Room. Technical data defining detailed requirements are presented in Section 4 of (CLSP, 6.1). [S1]

3.2.4.2 Display Surfaces. Portions of exposed interior walls may be surfaced with material suitable for temporarily mounting or exhibiting reference materials such as illustrations, maps, charts, schedules, and other instructional software. The material selected shall not degrade or disintegrate with long-term use of push-pins or other mechanical fasteners or with adhesive-backed tape for mounting display materials. [C2]

3.2.4.3 Chalk Boards. Portions of interior walls may be surfaced with material suitable for use as chalk boards, or alternatively, at least one interior wall shall be designed to permit the mounting of one or more commercially-available chalk boards for use by discussants. Figure 3-3 illustrates the preferred locations for such equipment in a typical room layout (Morgan, 6.2). [S2]

3.2.4.4 Projection Screens. At least one, and preferably two projection screens shall be installed in the Discussion Room for displaying visually-mediated software. Screens shall be permanently installed, i.e., wall or ceiling mounted, and stowable to prevent damage when they are not in use. They shall be readily accessible for unrolling or deployment and stowage by students as well as the discussion group teacher. Detailed performance requirements are presented in 3.6.4. [C1]

3.2.4.5 Reflectance Values. Surface reflectance values for interior Discussion Room surfaces shall conform wherever possible with the values shown in Table 3-2. Matte finishes shall be used on work surfaces in order to diffuse incident light. Large expanses of interior surface, such as enclosure walls, shall be finished with non-glossy surface treatments in non-saturated or relatively pastel colors. Natural wood may be used, providing the typically low reflectance values shown in Table 3-3 are acceptable in the locations in which the wood finishes are to be used. (Woodson, 6.3) [S2]

Table 3-2
SURFACE REFLECTANCE VALUES

Surface	Acceptable Range (%)	Optimal (%)
Enclosure walls	40 to 60	50
Work surfaces	15 to 30	15 (Min.)
Installed cabinetry	25 to 35	30

Table 3-3
APPROXIMATE REFLECTANCE VALUES FOR WOOD FINISHES

Surface Finish	Reflectance (%)
Maple	42
Satinwood	34
English Oak	17
Walnut	16
Mahogany	12

3.2.5 Lighting Equipment Interface

Discussion Room illumination requirements are specified in Section 4 of (CLSP, 6.1). Interior walls may be used for mounting additional fixed or adjustable lumenaires to supplement general lighting installed in the instructional facility. Electrical wiring serving lighting fixtures permanently mounted to enclosure walls shall be concealed to prevent tampering and accident damage. In the case of hollow wall construction, wiring shall be installed within the hollow core. Fixtures and lighting shall meet the general requirements of applicable underwriters codes. [C2]

3.2.6 Installed Accessories

Brackets, clothing hooks, and other small articles of hardware installed on Discussion Room walls shall be readily visible and accessible to the occupants, however, consideration shall be given to their configuration and placement in order to avoid accident injury during ingress, egress, and normal Discussion Room activities. [C1]

3.3 AIR CONDITIONING INTERFACE

The Discussion Room enclosure shall be designed to permit air circulated by the facility air conditioning system to flow into the room through strategically placed ventilators. Detailed system performance requirements are specified in Section 4 of (CLSP, 6.1).

3.4 WORK SURFACE DESIGN REQUIREMENTS

The Discussion Room shall incorporate a conference table or two or more smaller tables that can be combined into an arrangement suitable for small group discussions, and one or more secondary work surfaces as defined in 1.5.2 above. Student anthropometric dimensions shall be used for the design of these furnishings in accordance with 3.1. [S1]

3.4.1 Primary Work Surface

The primary work surface shall be the horizontal table top located at the preferred height for writing and other manual tasks, and sufficiently high to provide adequate clearance over the thigh of the largest seated student: Optimal Work Surface and Thigh Clearance Heights as shown in Fig. 3-4 and Table 3-3 are: 97.5th percentile: Minimal Work Surface and Thigh Clearance Heights: 95th percentile (Martin, 6.4). [S1]

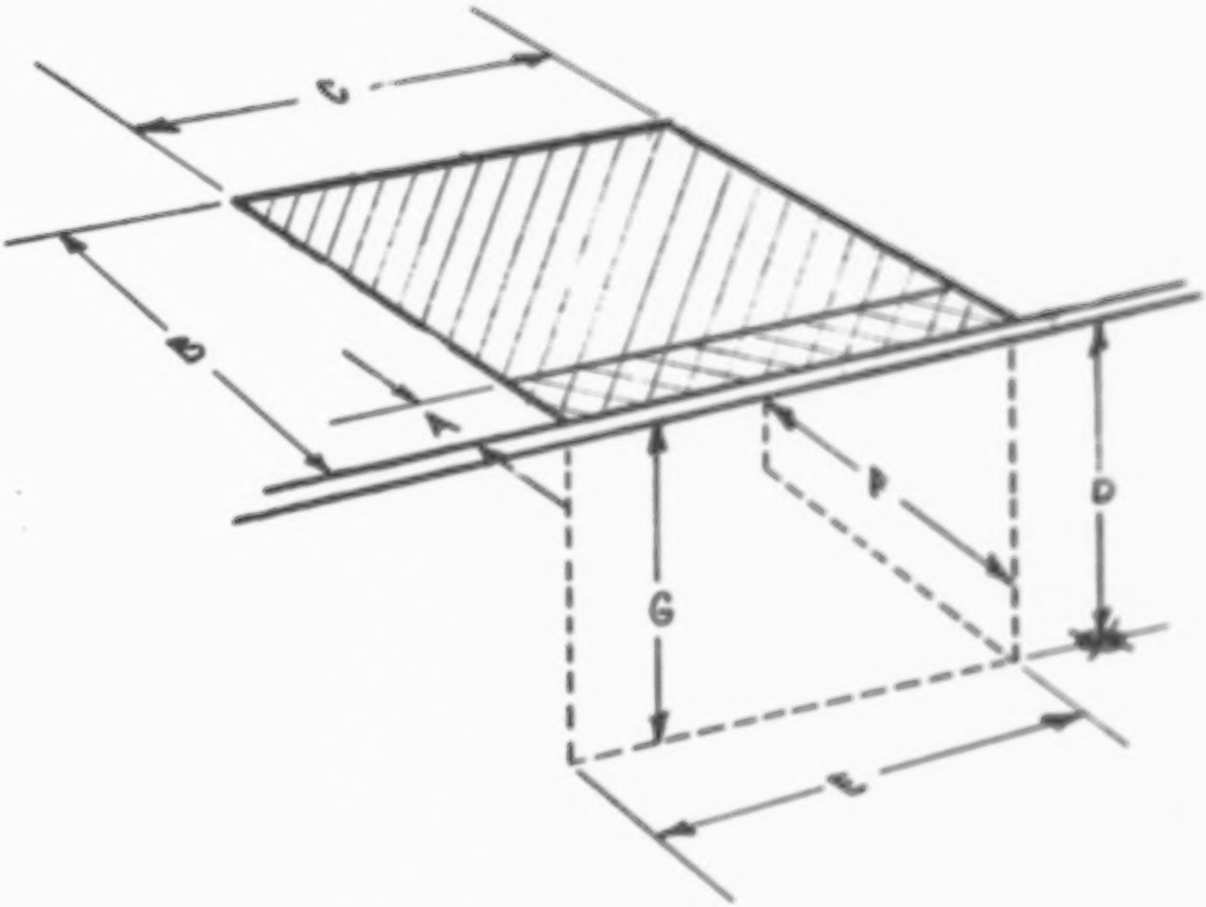

Fig. 3-4 Discussion Table Workspace Dimensions

3.4.2 Secondary Work Surfaces

Secondary work surface and clearance heights shall conform to the requirements of 3.4.1 above. (Martin, 6.4) [81]

3.4.3 Knee and Foot Room

Adequate knee and foot room shall be provided beneath the primary work surface to accommodate the seated student as shown in Fig. 3-4 and Table 3-4: Optimal: 97.5th percentile; Minimal: 95th percentile. (Martin, 6.4) [81]

3.4.4 Table Workspace Dimensions

When a conference table arrangement is used as the vehicle for small group discussion activities, each discussant shall be provided with a primary work surface wide enough to accommodate the largest seated occupant in his preferred writing position plus an allowance for books, notebooks, and other study materials arranged in a convenient display for ready reference: Optimal Work Surface Width: 97.5th percentile + 12 in.; Minimal Work Surface Width: 95th percentile. Work surface depth shall permit the smallest occupant to reach study materials located at the limits of his functional reach: Optimal Work Surface Depth: 2.5th percentile + 12 in.; Minimum Work Surface Depth: 5th percentile functional reach. These dimensions are shown in Fig. 3-4 and Table 3-4. (Martin, 6.4) [81]

3.5 SEATING DESIGN REQUIREMENTS

The Discussion Room shall include a chair for each of the 10 occupants. Chairs shall provide comfortable support for the body in the range of sitting positions preferred for reading, writing, viewing audio-visual materials, and discussion activities. They shall be free-standing, self-supporting, and castered to permit freedom of movement within the room, and shall incorporate permenent armrests. They shall be capable of being removed from the room for occasional use elsewhere in the instructional facility. The general requirements established for Carrel seating shall be applied to the design of new chairs for the Discussion Room or to the selection of commercially-available chairs intended for use in the Discussion Room. These requirements are specified in Sections 3.6.2 through 3.6.5 and in Tables 17 and 18 of (CLSP, 6.7). [82]

Table 3-4

PREFERRED PRIMARY WORK SURFACE DIMENSIONS

Primary Work Surface Dimension[a]	Type of Dim.	Minimal Dim. (in.)	Optimal Dim. (in.)	Allowance Dim. (in.)	Recommended Dimension (in.)
A. DEPTH of work surface, elbow rest only	Incl	4.2	4.7	-	4.7
B. DEPTH of work surface, desk work area	Excl	27.6	26.9	+1.1	28.0[b]
C. WIDTH of surface, flat	Incl	29.1	29.9	+0.1	30.0
D. HEIGHT of work surface	Incl	30.6	31.4	-	31.4
E. WIDTH of kneehole	Incl	14.2	18.6	+5.4	24.0
F. DEPTH of kneehole	Incl	31.8	31.9	+0.1	32.0
G. HEIGHT of kneehole	Incl	27.1	27.8	+2.0	29.8

[a] Minimal accom. range is 90 percent; Optimal accom. range is 95 percent.

[b] Additional allowances must be made for audio-visual displays and storage volumes in front of the occupant at work surface level.

3.6 INSTRUCTIONAL HARDWARE DESIGN REQUIREMENTS

The Discussion Room shall be capable of accommodating various types of instructional hardware in the form of equipment for presenting verbal and pictorial educational materials in the course of small group discussion activities. Provisions for displaying printed materials are defined in 3.2.4.2.

3.6.1 Media Requirements

The primary means for presenting audio-visual mediated instructional software shall include the following:

- a) 2 in. by 2 in. 35mm Black and White and Color Slides
- b) Standard and Super 8mm Black and White and Color Motion Pictures
- c) Magnetic Sound Recording Tapes up to 1/4-in. in width
- d) 10 in. by 10 in. Transparency Overhead Projector

For purposes of this specification, these equipments shall be selected from commercially-available hardware, and shall be portable rather than permanently installed within the Discussion Room, or within an adjacent projection booth. A mobile (roll-around) console shall be provided to accommodate at least two items of projection equipment listed above. Requirements for this system component are presented below.

3.6.2 Growth Potential

During Discussion Room design, consideration shall be given to the future accommodation of improved versions of the above equipment, and to the use of advanced System C audio-visual equipment concepts. Such systems may include:

- a) Black and White and Color Closed-Circuit Television
- b) Centralized Magnetic Recording Broadcast System Terminal Equipment

3.6.3 Operational Requirements

Minimal and Optimal equipment performance capabilities for Slide, Motion Picture, and Magnetic Tape Playback equipment are presented in (CLSP, 6.1). Performance capabilities for the Overhead Projector are presented in Table 3-5 below.

Table 3-5

OVERHEAD PROJECTOR EQUIPMENT CAPABILITIES

Capability	Performance Requirements	
	Minimal	Optimal
Transparency Insertion, Advancement, Reverse	Manual, one-at-a-time	Manual, one-at-a-time
Writing Roll Advancement, Reverse	Manual	Manual Remote Control
Random Transparency Selection	Manual	Manual
Random Writing Roll Frame Selection	Manual	Manual Remote Control
Sound Synchronization	None	None

3.6.4 Visual Media Display Requirements

3.6.4.1 Display Mode. The preferred mode for displaying 35mm slides, 8mm motion pictures, and transparencies shall be by front-screen projection. As specified in 3.2.4.4, at least one projection display screen shall be provided in the Discussion Room. [C1]

3.6.4.2 Display Screen Location. The projection display screen shall be positioned within the optimum visual envelope of the Discussion Room occupants, and located to facilitate viewing by all occupants without rearrangement of the primary work table or other furnishings exclusive of individual seats. (Morgan, 6.2) [S2]

3.6.4.3 Screen Size and Proportions. The projection-display screen shall be proportioned to accommodate the formats of media shown in Table 3-6 below.

The physical size (height and width dimensions) of the screen may vary considerably and still be adequate for presenting mediated instructional materials. Factors to be considered in selecting an optimal screen size are presented in Section 3.6.4.4 of (CLSP, 6.1) and accompanying figures. [S2]

Table 3-6

PROPORTIONS OF MEDIA FORMATS

Medium	Format Width	Format Height
35mm Slides (1.375 in. × 0.9075 in.)	1	0.6610
8mm Standard Motion Pictures	1	0.736
8mm Super Motion Pictures	1	0.75
10 in. × 10 in. Transparencies	1	1

3.6.5 Projection Console

Discussion Room furnishings shall include a small, free-standing, mobile console designed to serve as the stand for instructional hardware when these are required to present audio-visual materials during small group discussion activities. This unit will obviate the need to place items of instructional hardware on the primary work table, and thus avoid the identification of a specific workplace at the table as the teacher's. The console shall incorporate a single, 110 vac, 60 cycle power cord for connection to the Discussion Room electrical power system, and at least three installed outlets for supplying power to three items of equipment placed in or on the console. At least two projectors shall be capable of being accommodated in the console simultaneously to permit the use of two types of visually- mediated instructional materials during a single discussion period. The console shall incorporate a magnetic tape playback system, and an installed loudspeaker system compatible with tape reproduction and motion picture sound track reproduction systems. The console shall incorporate a control/display panel comprising controls for all permanently-installed terminal equipment. In the optimized Discussion Room, all instructional hardware shall be capable of being operated remotely, as specified in 3.6.3 above, and 3.6.3.3. of (CLSP, 6.1). When equipment is procured to comply with these optimal requirements, the remote operating controls for equipment to be used in the Discussion Room shall be integrated into the projection console control/display panel. Control/display panel design requirements relevant to the Optimal console configuration are presented in Sections 3.6.5.1 through 3.6.5.6 of (CLSP, 6.1). [C1]

3.6.6 Audio Media Presentation Requirements

The optimal Discussion Room audio system should be capable of presenting audio-mediated instructional materials from motion picture optical sound tracks, motion picture magnetic sound tracks, and magnetic-taped software, and of presenting audio output from closed-circuit student/teacher or broadcast systems through the same loudspeaker terminal equipment installed in the projection console. The minimal audio presentation system will permit the manual switching of audio output from any of these sources without eliminating the redundancy of playback and amplification subsystems integrated into each separate type of audio reproduction equipment. For purposes of this specification, the minimal system shall be assumed: independent magnetic tape recording/reproduction equipment, and independent projection equipment. Basic operational requirements for the magnetic tape reproduction equipment are presented in 3.6.3.3 of (CLSP, 6.1). [C1]

4.0 DISCUSSION ROOM/INSTRUCTIONAL FACILITY INTERFACES

In addition to the structural interface between the Discussion Room and the instructional facility, the Discussion Room will be dependent upon the facility for heating, cooling and circulation of ventilating air, for lighting, and for acoustical noise control. The requirements established in Section 4 of (CLSP, 6.1) apply to this specification and will not be duplicated in this document. [S1]

5.0 DISCUSSION ROOM/SUPPORT SYSTEM INTERFACES

The general requirements relating to design for accessibility and maintainability of equipment presented in Section 5 of (CLSP, 6.1) apply to this specification and will not be duplicated in this document. [S1]

6.0 REFERENCES

6.1 Cubberley-Lockheed Science Project, Carrel Design and Performance Requirements Specification, Biotechnology and Education Systems, Lockheed Missiles & Space Company, Sunnyvale, California, January 15, 1968

6.2 Morgan, C. T., A. Chapanis, J. S. Cook, and M. W. Lund, Human Engineering Guide to Equipment Design, New York: McGraw-Hill Book Company, 1963

6.3 Woodson, W. E. and D. W. Conover, Human Engineering Guide for Equipment Designers, Berkeley: University of California Press, 1964

6.4 Martin, W. E., The Functional Body Measurements of School Age Children: A Handbook for Manufacturers, Design Engineers, Architects, and School Officials for Use in Planning School Furniture, Equipment and Buildings, Chicago: National School Service Institute, 1954

PART IV

INSTRUCTIONAL PACKAGE SPECIFICATION

1.0 INTRODUCTION

1.1 SCOPE

This document sets forth requirements for the formatting and contents of an instructional package for Phase II of CLSP.

1.2 PURPOSE OF AN INSTRUCTIONAL PACKAGE

The purpose of an instructional package is to make available a specified unit of material as an instructional entity. By instructional entity is meant that procedural requirements for the use of the package by both teachers and students are stated, pre and post examinations are made available, and the entire package instructional content is mediated and included in the package. For example, an instructional package concerning "Matter and Energy" may be developed as a sequence for a course in Earth Science, and may be used by itself in a course in Biology just prior to another package on the origin and processes of living organisms. Or, an instructional package may be developed on a single, specific topic such as, How to Write Instructional Objectives. In any case, a package constitutes a complete unit of instruction in itself.

1.3 APPLICABLE DOCUMENTS

The following documents form a part of this exhibit to the extent specified herein:

Equipment/Facility Specifications – (Parts II and III)
Media and Mode Specification (Part V)
Evaluation Specifications (Part VI)

1.4 APPLICABLE DEFINITIONS

The following definitions are applicable to this specification:

Content – The materials included in the package of an illustrative, conceptual or factual nature, and the accuracy and recency of such data.

Behavior – The overt and/or implicit responses of the learner.

Behavioral Objectives – A specification of the type of response(s) (terminal behaviors) the student will demonstrate, when given selected stimulus material, at the time the instructional influence ends.

Instructional Objectives – A description of the intended outcome of instruction in terms of the following categories: behavioral objectives, content, conditions (for demonstrating knowledge of content), and criterion (evaluation).

Conditions – Information either given to or withheld from the student when he is demonstrating terminal behaviors relative to some specified content.

Criterion – A level of acceptable (passable) student performance which the student must meet in order to continue on to new material. The performance may be in terms of: power tests, time limit tests, number of principles that must be identified, words spelled correctly, etc.

Concept – An internal mediator representing common properties of objects or events which enable discrimination from other objects or events. Concepts are usually represented by a word or a name.

Test – A sample of the performance of a person on a task or set of tasks at a specific, complex level.

Quiz – A sample of the performance of a person on a task or set of tasks at a general, simplified level.

Achievement – Accomplishment on a test of skill or knowledge using present skills or knowledge.

Affective Domain – A person's subjective, introspective, emotional state. This includes the person's awareness or attention, responsiveness, values, and general life style.

Rentention	The process of remembering what has been learned as evidenced by some measure of : savings, recognition, and/or recall.
Instructional Mode	The arrangement of media in relation to the student, eg. tutorial sessions, lectures, quiz, discussions, laboratory, homework, field trips. In short, group size and instructional technique.
Individualization of Instruction	An educational position which endeavors to hold the student/teacher ratio at one to one. To this end the content is mediated individually, and the student is allowed to progress at his own rate.
Small Group Discussion	A mode of instruction in which a student – teacher ratio of ten-to-one is maintained. This mode is characterized by two way communications to achieve the goal of transfer (generalization) of acquired material.
Individualization of Laboratory	A mode of instruction in which the student/teacher ratio is one-to-one such that the Laboratory may be performed at any time during the course of instruction by any one student.
Self-Contained Classroom	The existent classroom setting in which lecture, discussions, and labs are performed in one room with a constant student/teacher ratio of about 30 to 1.
Instructural Media	Those components of the learning environment that generate stimulation to the student, e.g., Oral (live or recorded), Text (traditional or programmed), Graphics (slides, pictures, charts), three dimensional objects (models, specimens), and moving pictures (movies, video tapes).

2.0 GENERAL REQUIREMENTS

2.1 PACKAGE FORMAT

2.1.1 General Layout of Text

The layout of textual and illustrative material shall be positioned on 8-1/2 × 11 inch pages so as to be read when the longer dimension of the printed page is oriented vertically.

2.1.2 Diagram Arrangement

Diagrams shall be arranged in the order of the most general data to the most detailed data.

2.1.3 Front Matter

Front matter shall normally be included in the following sequence:

2.1.3.1 Title Page. The title page shall be oriented to a vertical format and include the title of the package, the date of its publication, and the author(s) and/or publisher.

2.1.3.2 Table of Contents. A table of contents shall be prepared which lists the package contents and the page number for each specific type of information.

2.1.3.3 Pre-test. Every package shall contain a pre-test following the table of contents. The form of the pre-test shall be dictated by the nature of the information required for use in the package.

2.1.3.4 Introduction. Every package shall contain an introduction following the pre-test.

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2.1.4 Pagination

2.1.4.1 Front Matter. All pages of front matter shall be numbered sequentially beginning with roman numeral "1."

2.1.4.2 Other Pages. All other pages of the package shall be numbered sequentially beginning with Arabic "1."

3.0 PRE-TEST

3.1 RATIONALE

A rationale shall be included with the pre-test and shall precede the test questions. The rationale shall indicate the usefulness of the pre-test as a diagnostic tool to individualize package content such that any student demonstrating mastery of a package subtopic may waive that particular section of the package and continue on. The rationale shall include the following: a description of the areas to be covered in the pre-test, instructions for taking the test, the method of scoring the test, and a minimum passing score required to begin work on the package.

3.2 CONSTRUCTION OF THE ITEMS TO BE INCLUDED IN THE PRE-TEST

The pre-test shall contain at least two questions for each instructional objective listed for the package.

The test items shall be constructed such that the student is required to use concepts to answer questions rather than content information peculiar to the package.

The items shall be constructed on the level of difficulty defined as, "test," in Section 1.4.

3.3 DIAGNOSTIC USE OF PRE-TEST RESULTS

At the conclusion of the pre-test, there shall be a diagnostic matrix which will indicate to the student (1) whether he has the background required to begin the package, (2) his probable area(s) of weakness and/or difficulty in the up-coming package, and (3) the areas in which he is competent enough to skip over with just a brief review. This matrix shall be divided into package subtopic areas including an area for requisite pre-package background. The scores for each subtopic shall be recorded in this matrix and shall be compared with Norm scores provided within the matrix.

4.0 PACKAGE

4.1 INTRODUCTION

The introduction to an instructional package shall include the following topics in the order specified herein: (1) the purpose, (2) a precis of the content, and (3) an outline of the major concepts.

4.2 PURPOSE

The purpose shall state the scope of the present package and its general goal(s). The introduction purpose shall state the relationship between the present package and precedent and antecedent packages.

The purpose shall contain a summary of the major behavior objectives to be acquired by the student at the conclusion of the package.

4.3 PRECIS OF COURSE CONTENT

The package introduction shall include a brief, concise narrative description of the package content.

4.4. OUTLINE OF MAJOR CONCEPTS

The introduction shall be concluded with an outline of statements covering the major concepts contained in the package.

5.0 TEACHER'S RATIONALE

5.1 OUTLINE OF TEACHING ACTIVITIES

The teacher's rationale shall include an outline of the package content in terms of class meeting. This class meeting schedule shall not be binding when applied to individually paced, self-instruction Carrels. The outline shall account for the following modes of instruction, content instruction, laboratory instruction, and group discussions, and shall indicate the approximate length of the package in time.

5.2 CONTENT INSTRUCTION REQUIREMENTS

Content instruction refers to a mode of presentation of material to the student. This mode shall be large group lecture for the self-contained classroom and individually presented and paced instruction for the individualized class. The media required for instruction shall be specificied for each instructional objective and shall be specified for the self-contained classroom and/or the individualized class. Media requirements shall be specified in terms of software (texts, worksheets, slides, etc.) and hardware (slide projector, tape player, motion picture projector, etc.) requirements.

5.3 LABORATORY

Laboratory refers to a mode of instruction in which the student actively participates in a scientific investigation. This mode shall include the entire class for the self-contained classroom and individual labs for the individually paced class. The media required for instruction shall be specified for each laboratory instructional objective in terms of self-contained classroom and/or the individualized class. Media requirements shall be specified in terms of software (lab manual, data sheets, etc.) and hardware (apparatus, motion picture projector, etc.) requirements.

5.4 DISCUSSION GROUP

Discussion group refers to a mode of instruction in which two way communication exists and interactions occur. Its primary purpose is transfer of learning. This mode shall include the entire classroom and groups of not more than ten students for the individualized class. Media requirements shall be specified in terms of software (printed handouts, slides, etc.) and hardware (slide projector, etc.) requirements.

5.5 ESTIMATE OF LENGTH OF PACKAGE

The outline of teaching activities shall be concluded with an estimate of the total length of the entire package as measured by time.

5.6 LEVEL OF DIFFICULTY OF INSTRUCTIONAL PACKAGE

The level of difficulty of the instructional package shall be rated on a scale from one (easy) to ten (very difficult) by the package author(s) and/or publisher. Along with this rating, prerequisites for beginning the package shall be stated. For example, a high school package on Matter and Energy may require a junior high school course in Earth Science.

5.7 CRITERION

A minimum level for student performance in mastery of the instructional objectives shall be stated for the package. A student must perform at this established minimum level before advancing on to the following package.

5.8 STUDENT PERFORMANCE LEVEL EVALUATION

Student performance shall be evaluated by the measures described in this section of the specification.

5.8.1 Achievement

A student shall be required to perform on an achievement test at a minimum level criterion established in Section 5.7 before being allowed to continue on to the next package.

5.8.2 Time to Complete Package

A student shall be required to complete a package in a liberal time period such that all packages can be completed by the end of the course.

5.8.3 Retention

A student shall be required to take and pass a test of retention at the completion of a course of packages. However, tests of retention for a given package may or may not be included in the package. In many cases, the pre-test shall serve as the test of retention as well.

5.8.4 Affective Domain

The teacher shall evaluate each student in the area defined as affective domain in Section 1.4. The importance of this evaluative tool shall be determined by the teacher.

6.0 STUDENT'S RATIONALE

A complete description of student responsibilities shall be provided in the Student's Rationale. This rationale shall include an outline of package activities, a description of package examinations, and a student evaluation sheet.

6.1 OUTLINE OF STUDENT ACTIVITIES

The student activity outline shall provide a syllabus of the package instructional content. This syllabus shall identify the sequence of instructional events and indicate the mode of instruction for each. It shall also indicate any extra-classroom student responsibility such as homework assignments and their due dates. This syllabus shall be structured by class meetings, but shall not be binding when applied to an individually paced class.

6.1.1 Class Participation

The student shall be provided with information indicating the degree to which his participation in group discussion (small or large) will determine his acceptable completion of the package. The purpose of this requirement is to impress upon the student the function of group discussion (transfer) and its relation to performance on examinations.

6.1.2 Class Assignments

The student shall be provided with information indicating the degree to which his completion of class assignments will determine his completion of the package. The student shall be informed of the minimum level of competence acceptable for such assignments.

6.1.3 Work Sheets

The student shall be provided with information indicating the function and importance of the work sheet. Information regarding requirements for successful completion and grading (if applicable) shall be provided.

6.1.4 Laboratory Assignments

The student shall be provided with information regarding the purpose of laboratory assignments with respect to the package. They shall be informed of the degree to which their laboratory performance will affect their successful completion of the package and of the criteria for grading such assignments. Additional specific laboratory requirements for the student shall be stated herein where applicable.

6.1.5 Homework

The student shall be provided information regarding package requirements for the completion of, the submittal of, and the grading of homework. He shall also be informed of the policy for late, incomplete, no homework.

6.1.6 Estimate of Length of Package

The student's rationale shall provide an estimate of the total length of the entire package as measured by time. The student shall be informed as to whether this estimate is binding.

6.2 EXAMINATIONS

6.2.1 Sequence of Examinations

The title for each test and quiz to be given during the course of the package shall be listed sequentially in the order in which they are to be administered.

6.2.2 Types of Questions

For each test or quiz, examples of questions included therein shall be provided for the student. The questions shall represent the type, scope, and depth of questions to be given on the test or quiz. The purpose for this requirement is to provide the student with a study guide and to reduce the effects of learning how to answer unfamiliar question forms.

6.2.3 Minimum Level of Acceptable Performance

For each quiz or test, the minimum level of performance which will be considered as passing shall be stated in terms of percentage correct or number of correct answers.

6.3 STUDENT'S EVALUATION SHEET

6.3.1 Rationale

The Student's Rationale shall contain a Student's Evaluation Sheet. This sheet shall provide the student with:

(1) information regarding sections he is required to complete,
(2) an area for accounting for the completion of each requirement,
(3) an area to record a grade and/or score, if applicable.

6.3.2 Format Layout

An 8-1/2 × 11 inch horizontal format shall be utilized for all student evaluation sheets.

6.3.3 Content

Student evaluation sheets shall contain the following data, as applicable, arranged in an order to facilitate conceptualization of the package sequence:

Pre-test Score
Introduction Read
Student's Rationale Read
Instructional Objectives Read
Instructional Unit(s) Completed
Quiz Scores
Post-test Score
Retention Test Score

7.0 HIERARCHY OF INSTRUCTIONAL OBJECTIVES

7.1 HIERARCHICAL LISTING

Instructional objectives shall be listed in a hierarchical order such that the basic concepts precede and are required by the more abstract concepts. This ordering of instructional objectives shall define the sequence of instruction within the package.

7.2 CRITERIA FOR INSTRUCTIONAL OBJECTIVES

An instructional objective shall be stated in such a manner as to account for the following data, as applicable:

Content
Behavioral Objective
Conditions
Criterion

7.3 RELATIONSHIP OF INSTRUCTIONAL OBJECTIVES TO EXAMINATIONS

Instructional objectives shall serve as the basis for constructing tests and quizzes. The purpose of this requirement for writing examination questions is to insure that the examination covers the material taught in the package. There shall be a minimum of two questions posed for each instructional objective. This requirement is set forth so that a reasonable sample of the student's behavior relative to an instructional objective can be obtained.

8.0 INSTRUCTIONAL PROGRAM

8.1 MODE

The mode of instruction for each instructional event in a package shall be designated by one of the following modes:

Individual Carrel
Large Group Lecture
Small Group Discussion
Large Group Discussion
Laboratory
Individualized Laboratory

The formatting of this material shall be governed by the mode specification.

8.2 MEDIA

The media for each instructional event in a package shall be designated in the manner specified in the media specification.

8.3 RATE OF LEARNING

Rate of learning shall be defined by the system utilizing the package. For the self-contained classroom system, the rate of learning shall (most probably) be governed by the average student. For the individualized class, the rate of learning shall be determined by the student, within liberal limits set up by the author and/or publisher of the package.

9.0 POST-TEST

9.1 RATIONALE

A rationale shall be included with the post-test and shall precede the test questions. The rationale shall indicate the use of the post-test as a test of the student's achievement in learning the content and behaviors contained in the package. The rationale shall include the following: a description of the areas to be covered in the post-test, instructions for taking the test, the method of scoring the test, and a minimum passing score required to continue on to the next package.

9.2 CONSTRUCTION OF THE ITEMS TO BE INCLUDED IN THE POST-TEST

The post-test shall contain at least two questions for each instructional objective listed for the package.

The test items shall be constructed such that the student is required to use concepts to answer questions at a specific, complex level of performance.

The items shall be constructed on the level of difficulty defined as "test" in Section 1.4.

9.3 EVALUATIVE USE OF THE RESULTS

The post-test of student achievement shall be used as the primary evaluative tool for determining the student's readiness to continue on to the following package.

10.0 TEST OF RETENTION

10.1 RATIONALE

A rationale shall be included with the test of retention and shall precede the test questions. The rationale shall indicate the diagonostic use of the test in determing how well the student retained the content and behaviors contained in the package. The rationale shall include the following: a description of the areas to be covered in the pre-test, the minimum passing score, and the use of that score with relation to the semester's grade.

10.2 CONSTRUCTION OF THE ITEMS TO BE INCLUDED IN THE PRE-TEST

The test of retention shall contain at least two questions for each instructional objective listed for the package.

The test items shall be constructed such that the student is required to use concepts to answer questions rather than content information peculiar to the package.

10.3 EVALUATIVE USE OF THE RESULTS

The use of the results of the test of retention shall be governed by the Evaluation Specification. The primary use of this test is the evaluation of the student's acquisition of the specified behavioral objectives.

PART V

INSTRUCTIONAL MEDIA AND MODE SPECIFICATION

1.0 INTRODUCTION

1.1 SCOPE

This document identifies the categories of media applicable to individualized instruction and sets forth the requirements for selecting media of a given category, for matching media to conditions of learning, and for mixing categories of media. The document also identifies the categories of mode applicable to Phase II and establishes the requirements for selecting mode, for matching mode to conditions of learning, and for matching mode and media.

1.2 PURPOSE OF INSTRUCTIONAL MEDIA

Instructional media have been defined as those components of the instructional environment which generate stimulation to the student. In traditional education the teacher has been the primary media source. However, the educational philosophy adopted by this specification is that there are other media sources equally as well or perhaps better equipped to generate stimulation to the student than the teacher. The purpose, then, of media utilization is to free the teacher as a media source so that he may interact on an individual level with the student.

1.3 PURPOSE OF INSTRUCTIONAL MODES

Instructional mode has been defined in the Instructional Package Specification as a particular arrangement of media with relation to the student. Instructional modes reflect an educational philosophy such as individualization and delineate the structure of the instruction system. The purpose of instructional modes is to establish the optimal student-media ratio for a specific condition of learning.

1.4 FUNCTIONS OF INSTRUCTIONAL MEDIA

The primary function of instructional media is to generate stimulation to the learner. This primary function can be divided into specific sub-functions. The following is an enumeration of these sub-functions as set forth by Gagne (1965):

(1) Present stimuli
(2) Direct attention and learning activity
(3) Provide a model for terminal performance
(4) Furnish external prompts
(5) Guide the direction of thinking
(6) Induce transfer of knowledge
(7) Assess learner attainments
(8) Provide feedback

1.5 FUNCTIONS OF INSTRUCTIONAL MODES

The primary function of an instructional mode is to optimize the arrangement of media in a learning environment with respect to the nature of the stimulus material and the number of students. This function, therefore, sets limits on the learning environment in terms of the student-teacher (or media) ratio, the types of applicable media, and the design of the instructional facility.

Secondary functions of instructional modes may include motivational and social considerations. Motivational aspects of mode may include aesthetic design of Carrels and small group discussion rooms or a one-to-one student-teacher interaction. The selection and design of various instructional modes can serve to increase social interaction among students (eg., small group discussions with less than ten students) and thereby reduce feelings of intellectual and social isolation. Design, selection, and performance trade-offs involving primary and secondary functions shall be reconciled wherever possible in favor of the primary function of the instructional mode.

1.6 GENERAL CATEGORIES OF MEDIA

1.6.1 Natural Objects and Demonstrations

The term natural object refers to stimulus material having a one-to-one representation with the real world. Thus, in science, chemicals, measuring instruments, and different varieties of animals may be directly observed and, thus, qualify as natural objects. Demonstrations refer simply to the sequencing of natural objects into events. For example, the heating of water to its boiling point.

1.6.2 Oral Communication

Oral communication refers to stimulation via the spoken word. Traditionally the teacher served all of the functions listed in Section 1.4 of this exhibit. Many of these functions can be mediated by other types of instructional media.

1.6.3 Printed Media

Printed media refer to stimulus material presented via the printed word. Text books, programmed texts, work sheets, etc. all come under this category.

1.6.4 Graphics

Pictures, maps, or charts serve to display visually the stimulus situation. These media extend the potential set of stimuli beyond the use of natural objects.

1.6.5 Motion Pictures and Television

No attempt shall be made to separate motion pictures from television since they usually serve the same instructional function. Motion pictures and television expand the potential set of stimulus material beyond that available for demonstrations. These two media deal with events (changes in objects) and sequences of events.

1.7 GENERAL CATEGORIES OF INSTRUCTIONAL MODE

1.7.1 Lecture

This mode is characterized by oral communication of stimulus material. The lecture is limited to verbal stimuli unless other media are mixed with the oral presentation.

1.7.2 Group Discussion

This mode of instruction involves discussion of stimulus material which has been presented in some other mode/media environment. The discussion concerns itself with transfer (generalization) of what has already been learned.

1.7.3 Laboratory

Instruction in this mode is directly related to the media category, natural objects and demonstrations. The purpose of this mode is to enable the student to come into contact with real world objects and events in the school setting.

1.7.4 Field Trip

This mode is similar to the laboratory mode described above in its use of media. However, the purpose of the field trip is to enable the student to come into contact with real world objects or events in their natural environment.

1.7.5 Homework

This mode can be characterized by self-instruction and practice via printed media.

1.8 APPLICABLE DOCUMENTS

The following documents form a part of this exhibit to the extent specified herein:

Carrel Design and Performance Requirements Specification.

This document sets forth background information and media design and performance requirements for Phase II.

Instructional Package Specification.

This document sets forth applicable definitions and media/mode requirements for instructional agenda.

Small Group Discussion Room Design and Performance Requirements Specification.

This document sets forth the design and performance requirements for media to be utilized in this instructional mode.

Laboratory Design and Performance Requirements Specification.

This document sets forth the design and performance requirements for media to be utilized in this instructional mode.

The Conditions of Learning (1965).

This book by R. M. Gagne presents much of the learning and educational theory and data utilized by this exhibit.

Instructional Media: A Procedure for the Design of Multi-Media Instruction, A Critical Review of Research, and Suggestions for Future Research. (1967)

This book by L. J. Briggs et al. presents much of the learning and educational theory relevant to matching media with learning events. Data presented in this monograph has been used extensively throughout this exhibit.

1.9 APPLICABLE DEFINITIONS

All definitions as established in the Instructional Package Specification are applicable to this document. The definitions relevant to this exhibit are reproduced below.

Field Trip. A mode of instruction in which the stimulus materials are comprised primarily of natural objects and events occuring in their natural environment. No limit is placed on the number of students receiving instruction in this mode.

Homework. Any assignment for study or preparation outside of the classroom. Typically homework is done individually, but this should not be taken to imply that more than one student cannot work on an assignment.

Individualization of Laboratory. A mode of instruction in which the student-teacher ratio is one-to-one such that the laboratory can be performed at any time during the course of instruction by any one student.

Individualized Lecture. A mode of instruction in which a mode/media mix is presented whereby the learner receives novel stimulus materials individually, usually in a Carrel.

Small Group Discussion. A mode of instruction in which a student-teacher ratio of no greater than ten-to-one is maintained. This mode is characterized by two-way communication to achieve the goal of transfer (generalization) of acquired material.

Instructional Hardware. Any complex instrument, appliance, or piece of machinery which constitutes a portion of the learning environment.

Instructional Media. The components of the learning environment that generate stimulation to the student; e.g., oral (live or recorded), (traditional or programmed), graphics (slides, pictures, charts), and motion pictures (movies, video tapes).

Instructional Mode. The particular arrangement of instructional media in relation to the student; e.g., lecture, small group discussion, field trip, laboratory.

Instructional Software. Any printed matter, such as books and work sheets which constitute a portion of the learning environment.

Individualization of Instruction. An educational position which endeavors to hold the student-teacher ratio at one-to-one during instruction. To this end, the content is mediated individually and the student is allowed to progress at his own rate of learning.

Media Mix. A combination of two or more categories of media to optimize the presentation of stimulus materials.

2.0 GENERAL REQUIREMENTS

2.1 RELEVANCE OF MEDIA AND MODE

Relevance of media and mode to a specific condition of learning shall be the major objective of media/mode mix selection. Relevance shall be determined by models developed by this project and cited in Section 3.0 of this exhibit. Trade-offs among potential media/mode mixes shall favor the most relevant mix whenever possible. If the models identify more than one equally relevant mix and, if feasible, both mixes shall be developed and the student shall be allowed to choose the mix he prefers. If the production of more than one media/mode mix is not (least costly) feasible, the mix (easiest) to develop shall be selected.

2.2 SIMPLICITY OF MEDIA DESIGN AND SOFTWARE DEVELOPMENT

Simplicity shall be a major criterion for the selection of instructional media hardware. Structural and functional components of the media shall be of the simplest design that will fulfill the instructional requirements set forth for a particular medium.

Stimulus materials (instructional software) developed for mediation shall conform to the criterion of simplicity. Trade-offs in the selection of stimulus material from several candidates shall be based on this criterion.

2.3 STANDARDIZATION OF MEDIA AND INSTRUCTIONAL SOFTWARE

Media components, displays, labels, and general arrangement within a specified mode shall be uniform in order to permit common usage and maintenance. If it ever becomes necessary to install different models of a specified medium, their subsystems and components shall be interchangeable wherever possible to permit common usage, servicing and maintenance, and to reduce the cost of purchasing, repairing, or replacing unserviceable equipment.

Instructional software developed for use with a specified medium shall use a standardized general format as specified in Section 4.0 of this exhibit. Also, the materials used for reproducing the stimulus matter, such as film, tape, or print, shall be uniform as specified in Section 4.0 of this exhibit.

2.4 SAFETY

Consideration shall be given to structural, mechanical, and electrical safety factors and to the elimination of design features that could result in injury to persons using or maintaining the media or instructional facility (mode) or in damage to the media or the instructional facility (mode). Whenever cost-effectiveness analysis indicates that a medium design or performance requirement can be satisfied by commerically available equipment, the selection process shall include consideration of personnel and equipment safety features. Equipment having modes of failure that could result in damage to the user or facility should be avoided wherever possible.

3.0 MEDIA SELECTION REQUIREMENTS

3.1 CATEGORIES OF INSTRUCTIONAL MEDIA

The principal function of instructional media is to generate stimulation to the learner. This stimulation can be generated by instructional hardware and/or instructional software. This section sets forth, within these two broad areas, requirements for selecting instructional media within the general categories of media set forth in Section 1.6 of this exhibit. Requirements for the development of the stimulus material have been deferred to Section 4.0 of this exhibit.

3.1.1 Natural Objects and Demonstrations

Instructional media requirements are not available for this type of medium. Typically this medium is presented in either a laboratory or field trip mode of instruction. General requirements for laboratory, as established in the Laboratory Design and Performance Requirements Specification, shall govern the specification of requirements.

3.1.2 Oral Communication

The principal medium for generating verbal stimuli shall be magnetic sound tape recorders. The tape recorder shall be capable of accepting a standardized tape cassette with a minimum tape play duration of one-half of an hour per side at a speed of 1 7/8 ips. Operational requirements for the tape recorder are established in the Carrel Design and Performance Requirements Specification.

The instructor shall be considered a secondary medium for the generation of novel verbal stimuli. Wherever possible, the tape recordings shall be used to generate verbal stimuli in order to free the teacher for other functions. Finally, verbal stimulation by means of a motion picture sound track shall be considered in Section 3.1.4 of this exhibit.

3.1.3 Graphics

The primary medium for display of still visual stimuli shall be a 35 mm. slide projector accepting 35 mm. 2 1/2" × 2 1/2" slides. Color film shall be used wherever possible for producing slides. In addition, photographs, pictures, charts, and maps shall be used as secondary still visual displays. The specific requirements for graphic representation of this nature shall be dictated by the nature of the stimulus material to be presented and space limitations of the instructional facility as set forth in the Carrel Design and Performance Requirements Specification.

Operational requirements for the primary graphic medium, slides, have been set forth in the Carrel Design and Performance Requirements Specification. These requirements shall apply to this exhibit.

3.1.4 Motion Pictures and Television

Motion pictures shall constitute the predominant source of visual stimuli for the display of events and sequences of events. These events shall be displayed by means of single concept films wherever possible. The primary equipment medium for generating this type of visual stimuli shall be Super 8-mm motion picture film and projectors. The film shall be Super 8-mm color wherever feasible. Secondary hardware media shall be either 8-mm or 16-mm motion picture film and projectors. All projectors shall be capable of generating audio stimuli in synchronization with visual stimuli to enable relevant media mixes. Based on cost-effectiveness criteria, television shall not be considered, at this time, as a media in the present exhibit. Tradeoffs between media hardware shall be made in favor of Super 8-mm color and sound media wherever possible.

Operational requirements for this type of visual media have been set forth in the Carrel Design and Performance Requirements Specification. These requirements shall apply to this exhibit.

3.1.5 Printed Media

Printed language shall be utilized as a primary source for generating stimulus material. There shall be no limits placed on the use of this medium beyond that of relevancy as set forth in Section 2.1 of this exhibit. Examples of printed media include textbooks, programmed texts, work sheets, direction, pamphlets, tests, etc.

3.2 MIXES OF INSTRUCTIONAL MEDIA

Media mix has been defined as a combination of two or more categories of media to optimize the presentation of stimulus material. For example, printed text material alone may become excessively verbal. However, when combined with a graphic media such as a picture or diagram, the text can generate a great deal of instruction in a short period of time. The most familiar media mix is the traditional teacher-blackboard combination.

3.2.1 Determination of the Number of Possible Media Combinations

The number of media combinations shall be described by the following formula:

$$\frac{N!}{k!\ (N-k)!}$$

N! refers to the total number of media categories and k! refers to the number of categories to be combined. Generally two categories, such as graphics and oral communication, serve as a media mix. In such cases, the number of possible media combinations (taken two at a time) shall be found by the formula, $\frac{n(n-1)}{2}$, where n is the total number of media categories to be combined. Refering to Section 1.6 of this exhibit, the total number of media categories is 5. Thus there are $\frac{5\ (5-1)}{2}$ or 10 possible media mixes. The relevant media mixes based on the categories of media established in Section 3.1.1 and 3.1.2 of this exhibit are summarized in Table 5-1.

Table 5-1

RELEVANT MEDIA MIXES, COMBINATIONS TAKEN TWO AT A TIME

Media	Oral Communication	Printed Media	Graphics	Motion Pictures
Natural Objects and Demonstrations	(1) Tape description of object or demonstration.	(1) Programmed text refering to each object or demonstration.	(1) Slides combined with natural objects to give display of object population.	(1) Motion P combined with display of natural objec
	(2) Teacher's description of object or demonstration.	(2) Directions for observing object or demonstration	(2) Photographs combined with objects to give greater	(2) Motion pictures & demonstration to show event and sequence of events
		(3) Test based on objects or demonstration	(3) Pictures combined with objects	
			(4) Diagrams combined with demonstrations.	
Oral Communication		(1) Tape presentation keyed to printed directions or work sheets.	(1) Tape-slide presentation.	(1) Motion picture with sound track.
	————	(2) Teacher's presentation combined with printed outlines or work sheets	(2) Teacher-slide presentation	(2) Tape-motion pic. synchronous or non-sync. presentation.

Table 5-1 (Cont'd)

Media	Oral Communication	Printed Media	Graphics	Motion Pictures
		(3) Alternation of these two media to reduce monotony of a single media.	(3) Tape-photograph, chart, picture, or map presentation. (4) Teacher-photograph, etc. . .	(3) Teacher motion pic. presentation.
Printed Media	———	———	(1) Text material with photographs, charts, maps, diagrams, etc. (2) Programmed text & slides, pictures, etc. (3) Instructions & diagrams.	(1) Filmed printed media introducing portions of the film or summarizing concept(s).
Graphics	———	———	———	(1) Instructional type films of graphic demonstration of some descrete sequence of events (steps). Eg. How to print more than one color using the slik screen technique.

3.2.2 Combination of Two or More Media

Table 5-1 summarizes relevent media mixes taking two media at a time. It is apparent from this table that there are greater than two relevant combinations. An example of a three media mix is a combination of motion pictures of printed material with a sound dialogue. As the number of different media combined increases, the number of relevant media mixes decreases at a disproportionally greater rate. Media mixes shall be employed wherever the combination of two or more media enhances the presentation of the simulus material as determined by media-learning models and empirical evidence.

3.3 SELECTION OF INSTRUCTIONAL MEDIA

The selection of a category or categories of instructional media for display of stimulus material shall be based on the relationship of instructional media to the conditions of learning indigenous to the stimulus material. The conditions of learning shall include the cases listed in Section 3.3.1 of the present exhibit (after Gagne, 1965). Media-conditions of learning matches shall be based on the data presented in Table 5-2.

3.3.1 Conditions of Learning

3.3.1.1 Signal Learning. This condition is similar to Pavlov's classical conditioning where the unconditioned stimulus is paired with a neutral stimulus which, in turn, becomes a signal for the response once elicited only by the unconditioned response.

3.3.1.2 Stimulus-Response Learning. This condition is similar to Skinner's Operant Conditioning where the learner performs an act instrumental in achieving a reward.

3.3.1.3 Chaining. Described in Table 5-2.

Table 5-2*

RELEVANT MATCH OF MEDIA WITH CONDITONS OF LEARNING†

Conditions of Learning: Instructional Events	Media
Chaining:	
a) Presenting cue stimuli in sequence	a) Natural Objects and Demonstrations
b) Appraisal	b) Same
Verbal Association:	
a) Presenting cue stimuli in sequence	a) Printed media or oral communication to supply means of practice, reinforcement, and appraisal
b) Confirmation of responses	b) Same
c) Appraisal	c) Same
Multiple Discriminations:	
a) Presentation of individual stimuli one by one	a) Natural objects or graphics
b) Progressive part practice	b) Same
c) Confirmation of responses	c) Same
d) Appraisal	d) Same
Concept:	
a) Presenting stimulus examples	a) Natural objects or graphics
b) Stimulating recall of individual (specific) links, usually verbal	b) Oral communication printed media or single concept motion picture
c) Appraisal	c) Natural objects or graphics
Principle:	
a) Inform learners about performance required	a) May require natural objects or graphics depending upon objectives
b) Stimulating recall of component	b) May be done by oral communication, printed media, graphics, or motion pictures
c) Appraisal	c) May require any or all categories of media described in Section 1.7 of this exhibit
Problem Solving:	
a) Inform Learner about performance required	a) Same as media for Principle
b) Stimulate recall of component concept	b) "
c) Verbal guidance	c) "
d) Appraisal	d) "

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*Portions of this table have been taken from Briggs, et al. (1967)

† Verification by empirical evaluation necessary.

3.3.1.4 Verbal Association. Described Table 5-2.

3.3.1.5 Multiple Discrimination. Described in Table 5-2.

3.3.1.6 Concept Learning. Described in Table 5-2.

3.3.1.7 Principle Learning. Described in Table 5-2.

3.3.1.8 Problem Solving. Described in Table 5-2.

3.3.2 Model for Matching Media with Instructional Objectives/Conditions of Learning

Wherever possible, the following general model shall be used to determine relevant matches of media with conditions of learning. For a unit of material, instructional objectives shall be identified. Instructional objectives have been defined as a description of the intended outcome of instruction in terms of the following categories: behavioral objectives, content, conditions (for demonstrating knowledge of content) and criterion of performance. Conditions of learning requisite for the achievement of each instructional objective shall be identified in a hierarchical manner starting with the easiest condition of learning for each instructional objective. Based on this hierarchical listing, media shall be matched to those conditions of learning based on the data presented in Table 5-2.

4.0 DEVELOPMENT OF STIMULUS MATERIALS FOR MEDIA

This section establishes general format and display requirements of stimulus material for media categories 1.6.2 through 1.6.5 found in this exhibit. The data presented in this section represent an initial attempt to establish general requirements. They should be updated wherever possible.

4.1 ORAL COMMUNICATION

4.1.1 Tape Recordings

4.1.1.1 General Format. All tape recorded stimulus material shall contain the following recorded format items:

(1) Title of the Instructional Package
(2) Section of that package being presented
(3) Titles and tape lengths of each subsection
(4) Special instructions for use of the tape

4.1.1.2 Recordings. There shall be a script for all recordings which shall be developed and reviewed prior to recording sessions. Whereever possible, the speed of the speaker's speech shall not exceed 3 words per second. The speaker shall enunciate each word and shall pause after announcing a slide, graph, work sheet, etc. which requires a response from the learner.

Control and display requirements have been described in the Carrel Design and Performance Requirements Specification. These requirements shall apply to this document for recording and playback of stimulus material.

4.1.2 Teacher

No specific speech requirements shall be placed on teacher's oral communication.

4.2 PRINTED MEDIA (TEXT MATERIAL)

4.2.1 General Format

All books shall be bound and shall use a 7-1/2 × 10-1/2 inch page with a total page thickness of 2 inches wherever possible. Typed materials, laboratory booklets, and other such text materials shall be bound in some manner and shall use an 8 1/2 × 11 inch page with a total thickness of 2 1/2 inches wherever possible. Page layout shall be governed by the fact that the reader enters the page from the upper left hand corner. Illustrations and headings shall be placed at the outer portions of each page so that they are readily available to the reader. At least a 1/2 inch outer margin after binding shall be provided with all text material. If more than one column is used, there shall be at least 1 pica of space between columns.

4.2.2 General Requirements

4.2.2.1 Style of Alphanumeric Print. No specific print type shall be required since most textbooks and many other text materials (and therefore type face) will be determined by the publisher. However, Bookman Old Style, Garamond, Cheltenham, Antique, and Scotch Roman shall constitute the population of type styles from which to base text selection. All text materials shall be printed in lower case standard type with appropriate capitals wherever possible. If this type is not available, then lower case boldface shall be employed. Wherever possible, this type shall be 10-point type. Tradeoffs shall favor print size ranging from 9 to 12 points.

Standard arabic numerals shall be used.

4.2.2.2 Length of Line. The length of the printed line shall be from 14 to 28 picas with 19 picas preferred. Given 10-point type style, 2-point spaces shall be employed.

4.2.2.3 Letter Height. Letter height for viewing at less than 28 inches under lighting of equal to or better than 1 foot-candle shall be 0.10 inches. However, where lighting conditions are less than 1 foot-candle, letter height shall be 0.20 inches.

4.2.2.4 Letter Width to Height. Letter-width-to-height shall be 3/5 wherever possible. Tradeoffs shall be made by reducing this ratio and also lowering the stroke-width-to-height ratio (Section 4.2.2.5 of this exhibit) in order to maintain clarity.

Arabic numeral letter-width-to-height shall be 1/1 wherever possible. Tradeoffs to 3/5 shall be acceptable.

4.2.2.5 Stroke-Width-to-Height Ratio for Print. A 1/6 to 1/8 stroke-width-to-height ratio shall be employed wherever possible. This assumes adequate lighting (greater than 1 foot-candle).

4.3 GRAPHICS

4.3.1 Slides

Color 35-mm 2 × 2 inch slides shall be employed for slide presentation of stimulus material. Format shall be dictated by subject matter governed by considerations described in Section 4.2.1 of this exhibit. When printed matter is utilized on the slide, the print shall be readable on the unprojected slide. This shall establish print size in the absence of empirical data. Print shall be in all capitals wherever possible on the slide.

4.3.2 Photographs and Drawings

Photographs and drawings shall measure 8 × 10 inches wherever possible. Tradeoffs shall be made in favor of Space Limitations as set forth in the Carrel Design and Performance Requirements Specification, the Discussion Room Design and Performance Requirements Specification, and the Laboratory Design and Performance Requirements Specification.

4.3.3 Maps and Charts

Requirements shall not be established beyond that of space limitations cited in Section 4.3.2 of this exhibit until further data has been generated. The establishment of format in the absence of requirements shall consider these three questions: (1) How will this medium be used, (2) When it will be used, and (3) For what will it be used.

4.3.4 Graphs and Tables

Graphs shall be utilized wherever shape of the function or interpolation are important. Graphs shall be constructed so that numbered grids are bolder than unnumbered grids. Every interval on the continuum shall not be numbered. Ten grid intervals are suggested wherever applicable.

Tables shall be reduced to their simplest form with the degree of sensitivity necessary to permit reading without interpolation. When table columns are long, numbers shall be separated into groups by providing a space between groups of five. At least 0.166 of an inch shall be provided between columns that are not separated by vertical lines.

4.4 MOTION PICTURES

Super 8-mm color film shall be employed wherever possible. Tradeoffs have been suggested in Section 3.1.4 of this exhibit. Primary emphasis shall be given to single-concept films.

4.5 QUALITY CONTROL OF DEVELOPED MATERIALS

Materials shall be reviewed prior and after production in a software to be used as media by the media specialist. The media specialist shall be required to insure all materials meet requirements specified herein.

5.0 INSTRUCTIONAL MODE

The principal function of instructional mode is to optimize the arrangement of media in a learning environment. The purpose of this section is to identify the mode-media mixes that optimize the learning environment and to elaborate the teacher's role in each mode setting. A description of the general categories of mode can be found in Section 1.7 of this exhibit. Additional design and performance requirements can be found in Parts II and III: Carrel Design and Performance Requirements Specification, Discussion Room Design and Performance Requirements Specification.

5.1 MODE-MEDIA MIXES

Mode-media mix shall be defined as the combination of one or more media with a particular mode. The educational philosophy of individualization of instruction shall guide the selection of all mixes. Table 5-3 presents the mode-media mixes.

5.2 TEACHER'S ROLE IN PHASE II BY MODE

5.2.1 Lecture (Carrels)

As indicated by Table 5-3, primary instructional emphasis in the lecture mode is given to all media with the exception of the teacher. The teacher's role in this mode shall be governed by the philosophy of instructional individualization. This philosophy allows the teacher to interact and instruct on a one-to-one basis with the student while allowing the student to progress through the course at his own rate. The teacher shall function as an additional information source himself or shall recommend additional resources. He shall give instructional assistance to a student when asked or when he ascertains from other evidence (e.g., the student's work sheet or performance in small group discussion) that the student does not have an adequate understanding of the stimulus material.

5.2.2 Small Group Discussion

Table 5-3 indicates that oral communication is the primary media source in this instructional mode. However, the emphasis is on equal oral communication among all participants in the small group discussion with a de-emphasis on the teacher as a participant. In this setting, the teacher shall function more as a stimulator of discussion by posing questions and, in this way, shall be able to keep the discussion oriented toward the material that has been presented in the other instructional modes.

Table 5-3

MODE-MEDIA MIXES
(The categories; low, medium, high, refer to the frequency and relevancy of mode-media mix)

Media	Natural Objects & Demonstrations	Oral Communication	Printed Media	Graphics	Motion Pictures
Lecture	Low	High	High	High	Medium
Small Group Disc.	Low	High	Low	Medium	Medium
Laboratory	High	Low	Medium	Low	Medium
Field Trip	High	Medium	Medium	Medium	_____
Homework	Low	Low	High	Low	_____

In addition to this, the teacher shall function as an information source for the students. Whenever discussion makes erroneous assumptions of fact or philosophy, the teacher shall provide information to correct this error. In a similar way, the teacher shall also function as arbitrator to settle a contested point in the discussion by providing additional information or recommending supplementary resources.

5.2.3 Laboratory

The teacher shall function in the laboratory mode of instruction in much the same manner as in the Lecture setting (Section 5.2.1 of this exhibit). He shall have the added responsibility of providing demonstrations where specifically required by the nature of the stimulus material.

5.2.4 Field Trip

The nature of the teacher's role in this instructional mode has not been defined to date. He shall probably be required to function as a guide, information source, and a primary media source. However, for individualized field trips, he shall simply supply the stimulus material to the student (e.g., tape recorder, tape, maps and pictures) and permit the student to take the field trip at his leisure.

5.2.5 Homework

The teacher shall provide homework assignments if not already mediated and shall check to see that all assignments have been completed.

PART VI

SPECIFICATION OF EVALUATION PROGRAM FOR PHASE II

1.0 INTRODUCTION

1.1 SCOPE

This document sets forth the evaluative techniques for measuring student behavioral change during the Phase II Pilot Study. This exhibit covers the following areas of evaluation: (1) General experimental design, (2) Subject population, (3) Sampling procedures, (4) Methods and procedures for collecting data, and (5) Statistical procedures for summarizing and interpreting data.

1.2 FUNCTIONS OF THE EVALUATION PROGRAM

The primary function of the evaluation program is to empirically demonstrate that the student has acquired specified terminal behaviors. This statement implies that any evaluative technique which functions to measure behavioral changes must be sensitive to and reflect the terminal behaviors. In addition to this function, the evaluation program will concern itself with teacher roles, mode-media matches, media-learning condition matches, mode-learning condition matches, media mixes, and human engineering design verification of facilities.

1.3 APPLICABLE DOCUMENTS

The following documents of issue in effect for Phase II form a part of this exhibit to the extent specified herein:

1.3.1 Specifications

1.3.1.1 Instructional Package Specification – Establishes presentation of instructional software stimulus configuration requirements.

1.3.1.2 Media-Mode Specification – Establishes media-mode requirements for the setting and presentation of stimulus material.

1.3.1.2 Carrel Design and Performance Requirements Specification – Establishes the carrel design and instructional mode and hardware requirements for this facility.

1.3.1.3 Discussion Room Design and Performance Requirements Specification – Establishes the discussion room design and instructional mode and hardware requirements for this facility.

1.3.2 References

1.3.2.1 Campbell, D. T. and Stanley, J. C., Experimental and quasi-experimental design for research on teaching. In Gage, N. L. (Ed.), Handbook of Research on Teaching, NewYork: Rand-McNally, 1963, 171-246. Establishes procedures for experimental design.

1.3.2.2 Edwards, A. L. Experimental Design in Psychological Research. New York: Rinehart & Company, 1958. Establishes procedures for experimental design and statistical analyses.

1.3.2.3 Hays, W. L. Statistics for Psychologists. New York: Holt, 1965. Establishes procedures for statistical analyses.

1.3.2.4 Edwards, A. L. Techniques of Attitude Scale Construction. New York: Appleton-Century-Crofts, 1957.

1.3.2.5 Gage, N. L. (Ed.) Handbook of Research on Teaching. New York: Rand-McNally, 1963. General reference for research.

1.4 APPLICABLE DEFINITIONS

All definitions as established in the Instructional Package Specification are applicable to this exhibit. The definitions relevant to this exhibit are reproduced below.

In addition to those definitions referred to above, the following definitions are applicable to this exhibit.

1.4.1 Achievement Test

A test of skill or knowledge using present skills or knowledge.

1.4.2 Analysis of Variance

A statistical procedure applicable to testing the hypothesis that several independent samples have been drawn at random from a common normal population.

1.4.3 Control Group

This term refers to a group (sample) of subjects receiving no experimental treatment (e.g., no instruction).

1.4.4 Dependent Variable

This term refers to the changes resulting from the experimenter's manipulation, e.g., achievement test scores due to a particular treatment.

1.4.5 Independent Variable

This term refers to that (those) variable(s) which the experimenter manipulates, e.g., System B vs. System A.

1.4.6 Population

This term is used in a broad sense to include all sets of individuals, objects, or reactions that can be described as having a unique pattern of qualities.

1.4.7 Random Sampling

The selection of a portion of a population where every individual (etc.) has an equal change of being selected.

1.4.8 Reliability

Reliability refers to consistency over time, trials, or items. The reliability of any set of measurement is logically defined as the proportion of their variance that is true variance.

1.4.9 Retention

The process of remembering what has been learned as evidenced by some measure of: savings, recognition, and/or recall.

1.4.10 Sample

A selected portion of a population.

1.4.11 Validity (Test)

The extent to which a test measures what it is supposed to measure.

2.0 GENERAL REQUIREMENTS

2.1 STUDENT BEHAVIORAL CHANGE

The primary emphasis in evaluating the CLSP System B instruction system during the Phase II Pilot Study effort shall be placed on the extent to which students acquire stated behavioral objectives. In other words, the degree to which any instructional system is effective depends ultimately upon the extent to which that system in fact changes behaviors which it set out to change. Tradeoffs in selection and interpretation of evaluative instruments shall be made in favor of those emphasizing the importance of student behavioral change.

2.2 EVALUATIVE TECHNIQUES FOR MEASURING STUDENT BEHAVIORAL CHANGE

Evaluative techniques shall cover the cognitive and affective domains of student behavior. These measures shall be sensitive to and reflect the specified student terminal behaviors. Trade-offs between measurement instruments shall be made in favor of those reflecting student behavioral change wherever possible.

2.3 RELIABILITY AND VALIDITY OF EVALUATIVE INSTRUMENTS

2.3.1 Reliability

Reliability refers to the extent to which an evaluative instrument is consistent in its measurements. Wherever possible, all evaluative instruments shall have demonstrated reliability. All things being equal, trade-offs among evaluative instruments shall be made in favor of the instrument with the highest demonstrated reliability.

2.3.2 Validity

Validity refers to the extent to which an evaluation instrument measures what it purports to measure. All evaluative instruments shall be developed on the basis of construct validity such that they investigate the extent to which the instrument tests for acquisition of stated terminal behaviors.

2.4 RANDOM SAMPLING

Experimental evaluation of any aspect of the Phase II Pilot Study shall satisfy the assumption of random sampling of test subjects. There shall be no trade-offs to this procedure wherever it is indicated.

2.5 EVALUATION OF REFERENT AND OBJECT SYSTEMS

Of primary concern with the referent system is the teacher's role in teaching under System B. Evaluation of the teacher's role in this system shall be based upon teacher's attitudes toward his new roles and teacher-student interaction. Human factors design verification shall determine hardware-facility (referent and object systems) requirements to optimize the performance of the student-teacher interface with facility and hardware.

3.0 PHASE II EVALUATION PROGRAM

3.1 GENERAL EXPERIMENTAL DESIGN

Treatment and control groups shall be drawn at random from the student population (Section 3.2 of this exhibit). The subjects shall be adminstered a pre-test wherever possible in a manner shown in Table 6-1. Following the pre-test, the subjects shall receive their respective treatments (control group = no treatment) and shall demonstrate stimulus material acquisition on tests of achievement and retention wherever possible. Time to cover the stimulus material shall also be measured as an indicator of performance. Questionnaires shall be utilized to elicit affective responses toward the experimental treatment.

Table 6-1

EXPERIMENTAL DESIGNS AND STATISTICAL ANALYSES

Design I	Design II	Design III
Pretest – Posttest with Control Groups	Posttest with Control Groups	Pretest – Posttest – Posttest only with Control Groups
Pretest → Baseline Posttest	Baseline Pasttest	Pretest → Baseline
Pretest → Individualization → Posttest	Individualization → Posttest	Pretest → Individualization → Posttest
Pretest → Control Posttest	Control Posttest	Pretest → Control Posttest (2)
		Pretest → Control Posttest ( )
		Baseline Posttest (4)
		Individualization Posttest (5)
		Control Posttest (6)
Statistical Analysis:	Statistical Analysis:	Statistical Analysis:
Analysis of covariance	Fixed model of the analysis of variance	(I) Base. Ind. Contr. Pretest 1 2 3 No Pretest 4 5 6 (II) Analysis of covariance

3.1.1 Experimental Design I

With this design, subjects shall be randomly distributed into experimental groups, given a pre-test, the specified form of instruction, and finally the post-test (Design I in Table 6-1). This design shall be extended to test for retention by using post-test scores as the covariate to the retention scores wherever possible. Both this design and Design III enable the experimenter to control not only for the main effects, but also for the effect of prior knowledge.

3.1.2 Experimental Design II

This design shall require only a post-test. Subjects shall be randomly distributed into experimental treatment and control groups, given the specified form of instruction, then given a post-test (Design II in Table 6-1). This design is the simplest relative to preparation and analysis time and can be justified based on random sampling. Wherever possible, this design shall be utilized with human factors design verification studies.

3.1.3 Experimental Design III

This design is a combination of Designs I and II. The subjects shall be randomly distributed into experimental treatment and control groups. Within each group, half of that group shall be selected at random to receive a pre-test. All subjects shall then receive the specified form of instruction, then given a post-test and a test of retention (using the post-test) as described in Section 3.1.1 of this exhibit (Design III in Table 6-1). With this model, both the main and treatment effects and the interactive effects of testing (pre and post) and the experimental treatment can be evaluated.

3.2 SUBJECT POPULATION AND SAMPLING PROCEDURES

3.2.1 Subject Population

The subject population shall be defined as those students taking biology, geology, and earth/life science courses at Cubberley Senior High School during the life of this project. The biology and earth/life science courses are taken, characteristically, by tenth grade students while geology is characteristically an eleventh grade course. All of the students defined in this population shall be affected by the Pilot Study phase of this project.

3.2.4 Sampling Procedures

The subjects shall be drawn at random from the course specific population of students. In other words, geology students shall be used to evaluate instructional systems effectiveness in teaching geology. Since satisfying the assumption of random sampling is absolutely necessary, scheduling problems shall be resolved such that experimental classes will have been assigned prior to the beginning of fall classes. In general, each course shall have a minimum of two classes participating in the experimental framework at a given time. All three courses shall be handled at the same time wherever necessary.

3.3. METHODS AND PROCEDURES FOR COLLECTING DATA

For the evaluation of instructional methodology for a given course, one class shall receive the baseline self-contained classroom treatment, another shall receive the "individualized" Study Center treatment, and a third group shall serve as the control group.

In general, there shall always be a no-treatment control group that will be evaluated (tested) without receiving any relevant instruction. The specific function of the control group(s) shall be defined by the experimental design alternative discussed in Section 3.1 of this exhibit. One other control deserving specific mention is the "teacher effect." By scheduling experimental classes prior to the fall semester (Section 3.2.2) this variable shall be controlled by having the same teacher instruct all groups being considered in the experiment.

3.3.1 Dependent Variables

The major dependent variables (measures of effectiveness) shall be: achievement (standardized test), time or rate of learning, retention (savings), and student and teacher responses to questionnaires. These questionnaires shall investigate the affective domain of the behavioral objectives as expressed in attitudes. Wherever a problem in interpretation arises due to a conflict in achievement scores and time to achieve, trade-offs shall be made in favor of the findings of the test of retention. If further interpretation is needed, this decision shall be left up to the Test Director.

3.4 STATISTICAL PROCEDURES

The statistical procedures accompanying the three experimental designs in Table 6-1 shall govern data summarization and interpretation. The statistical procedures shall be: Covariance (Design I), Fixed Model of the Analysis of Variance (Design II), and a 2 × 2 factorial design of the Analysis of Variance and analysis of covariance (Design III).

4.0 COMPARATIVE EFFECTIVENESS STUDIES OF SYSTEM ELEMENTS FOR PHASE II

This section focuses on the evaluation of specific system elements comprising the learning environment of System B.

4.1 INDEPENDENT VARIABLES FOR RESEARCH

The following are the major independent variables that shall be investigated during the Phase II Pilot Study:

- Media match to different content materials
- Comparison of different types of the same media
- Multi-sensory presentation
- Mode of instruction
- New teacher role

4.2 MEDIA

The evaluation of different media configurations set forth in Section 4.1 of this exhibit shall serve to reduce the size of the original list of media to basic media requirements and shall result in minimum media specifications for science courses and science study center Carrels. Experimental manipulation of different types (brands) of a given media as well as multi-sensory media shall be performed to achieve highest standards in: (1) control display and learning material; (2) reliability; and (3) cost-effectiveness. Most of this media evaluation shall be carried out within the framework of Experimental Design II (Section 3.1.2).

4.3 MODE

Selection of the mode of instruction shall be based on analysis of instructional objectives and the conditions of learning (Media Mode Specification). This selection shall involve the choice of large group discussion, lecture, laboratory, field trip, and homework for the self-contained classroom and a choice of Carrels, small group discussion, individualized laboratory, field trip, or homework in System B.

4.4 STUDENT TEACHER INTERACTION

In order to objectively describe the teacher's new role in System B, a teacher-student interaction analysis shall be performed using Bales Categories. Teacher satisfaction and evaluation of this new role shall be elicited by the use of a questionnaire(s).

5.0 MEASUREMENT OF ALTERNATIVE INSTRUCTIONAL SYSTEMS EFFECTIVENESS

A block of at least six weeks shall be set aside in the schedule of research for a total operational systems evaluation. During this period, the system individualizing instruction shall be compared with the self-contained classroom. The purpose of this evaluation shall be to determine whether the aim of this project – the development of a system to provide a learning environment which will assure that students achieve desired terminal objectives – has been realized. Experimental Desgin III, described in Section 3.1.3 of this exhibit shall set forth the experimental framework for this evaluation. Particular emphasis shall be placed on retention as a measure of effectiveness. In addition to retention, time to learn and achievement measures shall be collected and statistically analyzed. Special consideration shall be given to student and teacher affective responses to questionnaires. These questionnaires shall be concerned with the student and teacher acceptability of the new system, an evaluation of student teacher roles in the new system, a self evaluation of progress (in learning or teaching), and suggestions for modification of the proposed instructional system.

PART VII

PERSONNEL REQUIREMENTS

1.0 INTRODUCTION

At the heart of every system, instructional or otherwise, are the people who operate and maintain the system. Requirements for personnel to man the Phase II CLSP instructional system do not differ in kind from the personnel required for manning any system. Namely, personnel must perform three general functions:

1. Operate the system.
2. Manage and control the system.
3. Develop and revise new instructional materials and modify the system as required.

Personnel performing these general functions must operate at both the Reference and Object system levels.

Because the Phase II system is an experimental system, the specifications for personnel cannot be as precise as they would have to be for an operational system which is to be implemented in a variety of environments. As a result of this limitation, the specifications for personnel have been couched in functional rather than operational terms. No attempt has been made, for example, to develop a manning or organizational chart for implementing the system given a specified student load. Such data will be available as a result of evaluation of the results of the pilot program to be conducted during Phase II.

2.0 PERSONNEL FUNCTIONS

Analysis carried out within the CLSP indicates that the Phase II system will be characterized by three primary instructional modes:

1. Individualized mediated instruction provided through a variety of increasingly sophisticated technological capabilities.
2. Small group discussions and seminars to provide social interaction and experience, facilitate the development of higher order cognitive skills, and effect transfer of learning.

3. Individualized open laboratories to increase personal experience with the "real" world, to develop specific skills, and to understand the process of science.

To provide the desired inputs to these instructional modes the teacher must be capable of performing the following functions:

1. Serve as a discussion leader in small groups. The emphasis here will be on full student participation with no forcing of students into pre-determined paths of thought or opinion.
2. Counsel the students about their educational progress. It is obvious, of course, that such counseling is bound to extend into personal counseling since the learning experience of the student in the school is inextricably interwoven with his own personality development and the forces and factors outside the direct school environment.
3. Consultation and diagnosis of the student's progress within the specific subject matter area of concern. This activity should be separated from that of "counseling" since there are different skill elements involved. Consultation implies a degree of expertise and sophistication within the subject matter area which permits the teacher to provide sound guidance on the approach to be used in solving a specific research problem or to achieve resolution of a troublesome content area or concept development.
4. Function as a manager of both paraprofessional members of the instructional system and the student members of the object system. The relationship with the student in this capacity is one of guiding the student through the perils of academic bureaucracy to arrive at the desired place at the specified time. With regard to paraprofessional members of the instructional system, the teacher must perform all of those activities associated with sound management of any operational system.

The functions discussed above deal only with the operational aspects of the Reference system. Additional functions are required of the teacher, or at least of some selected teachers within the system. These functions are concerned with the provision of an adequate support system to the Reference and Object systems. In addition to providing management of personnel associated with the service and maintenance of the educational equipment and facilities, there is the requirement for the development and updating of instructional software. For the teacher, or systems development specialist, these functions include the following:

1. Analysis of instructional situations to identify appropriate behavioral objectives and the instructional events that will lead to their achievement.
2. Preparation of written materials and visual conceptualizations that can be translated into operational software for the system.
3. Consultation with media specialists and others to insure quality control in the development of instructional media.

3.0 POSITION DEFINITIONS

3.1 PROFESSIONAL

As indicated earlier, personnel position definitions, have been specified at the functional level only for the purposes of this exhibit. The positions defined below are, therefore, not to be construed as indicating a job occupied by any single person or group of persons. In implementing the system it may be necessary to combine functional descriptions into a single job, or alternately to spread the responsibility of a position among a number of persons. Although there is an implication of hierarchy in the position descriptions, no attempt has been made to specify the specific organizational structure for operation of the system. It should be pointed out, however, that the general approach to manning the system is based on a team concept. This team will include both professionals and para-professionals under the direction of a single team manager. In practical application of this concept a team manager may be responsible for a single course, a group of courses, or an entire department.

3.1.1 Team Manager

The teaching team manager shall be responsible for the scheduling, coordinations, and management of all members of the teaching and support team, and the students they serve. As such, he shall be competent not only in all the skills of the other members of the team but also possess managerial skills in directing the operations of a multi-disciplinary team. Management control shall be exercised downward through the teachers to the students, and in most cases directly to the para-professional members. He shall bear the primary responsibility for achieving specified effectiveness criteria by the students and shall have sufficient management responsibility to effectively carry out his assigned function.

3.1.2 Teacher

The teacher members of the team shall have primary responsibility for contact with the student via laboratory, small group discussion, and one-to-one interfaces with the students. The teacher shall be responsible to the team manager in accomplishing this primary function. The teacher shall possess the skills requisite to effective functioning in this prime responsibility. In larger teams this primary function may be divided into various specialties, e.g. discussion leaders, counselors, etc. In any team situation the teacher shall be provided with in-service training leading to eventual qualification as a team manager or instructional analyst.

3.1.3 Instructional Analyst

The instructional analyst shall be responsible for analyzing and evaluating instructional situations to determine appropriate instructional objectives and the required sequence of instructional events required by the students to achieve these objectives. He shall also be responsible for initial allocation of instructional events to the instructional mode and media best suited for the instructional event. He shall further be responsible for exercising a quality control function over the programming and mediation of instructional materials. A background in Instructional Psychology, either educationally or experientially, shall be mandatory for this position.

3.1.4 Instructional Programmer

The instructional programmer shall be responsible for preparing the draft materials to be contained in instructional materials. Instructional materials may include tape-slide presentation, programmed text, movie or TV scripts, or textual materials. He shall work in close coordination with the instructional analyst, teachers, and subject matter experts in accomplishing this function. He shall be familiar with instructional programming techniques, both linear and branching. He shall prepare rough sketches and layouts for the preparation of graphic materials.

3.1.5 Media Analyst

The media analyst shall be responsible for the translation of materials prepared by the instructional programmer into actual class-ready graphic materials. Dependent upon the quantity of preparations required he shall either accomplish this function personally or be responsible for obtaining the materials from commercial sources.

Dependent upon the specific situation in which the team is functioning, it may be possible to fill this position with a para-professional qualified in the graphic arts with appropriate experience in audio-visuals for instructional purposes.

3.2 PARA-PROFESSIONAL

Para-professionals are required, primarily as members of the Reference system element of the team to free professional teachers for student contact. Three categories of para-professionals have been identified for Phase II.

3.2.1 Teacher Aide

The teacher aide shall be responsible for providing direct support to the teaching members of the team under the administrative management of the team manager. In this capacity the teacher aide shall be responsible for specified secretarial, clerical, and procurement functions.

3.2.2 Laboratory Aide

The laboratory aide shall be responsible for direct support to the teachers in the preparation and conduct of laboratory exercises. He shall be responsible, under direction, for the preparation and maintenance of laboratory equipments and specimens and the check-out of both to students and teachers. He shall maintain adequate records on all equipments and specimens under his charge. He shall assist the teacher during laboratory exercises in providing supervisory control of the students, maintaining a safe laboratory environment, and providing consultive services to the students with regard to the operation of equipment and laboratory procedures.

3.2.3 Media Aide

The media aide shall be responsible for the maintenance and safe-keeping of all instructional software required for the operational classes. He shall be required to maintain adequate records of the location and condition of all instructional software. He shall be capable of performing simple maintenance of such software, e.g. film and tape splicing. He shall be responsible for the check-out of software to student and teachers. He shall also provide direct support to the teachers during the conduct of small group discussions and carrel exercises.

4.0 PROFESSIONAL TRAINING REQUIREMENTS

The resolution of the training problem must take into consideration not only the training of new teachers who have never experienced the "traditional" method, but also the retraining of teachers whose total experience is within the traditional framework. In Effect, we must plan for an evolving emergent instructional system. Analysis of the

Phase II requirements, supplemented by experience with the entry of other disciplines, e.g. Human Engineering, into the world of systems indicates the desirability of providing a thorough grounding in fundamental skills and knowledges at the undergraduate level of college with specialization reserved for in-service training. These fundamentals should include the following at the undergraduate level:

1. Traditional training in subject matter and instructional techniques. Since we are faced with a transition period of some duration, new teachers must be equipped to function effectively in traditional systems.
2. Intensive training in Learning Theory must be provided to all teachers. Although some training is provided in this area, experience with teachers indicates that this training is inadequate to the task of analysis of instructional situations, specification of instructional objectives, and structuring of instructional events to achieve the objectives.
3. Basic training in the fundamentals of technical writing. Such training should permit, minimally, effective communication with media specialists by the teacher. The emphasis in this course(s) should be placed on the problems and process of communication, rather than on specific presentational media.
4. Development of a working knowledge of the principles of perception, specifically perception of instructional media. Although training has been provided in Educational Psychology to teachers, effective training in the principles of perception, including social factors, has been strangely lacking.
5. Sufficient training in vocational and personal counseling to effectively deal with routine student problems and diagnose those situations requiring professional counseling assistance.
6. Fundamental training in managerial practices and theory that can be focused and solidified through additional in-service training for the specific managerial situation in an operating school.
7. Training in general systems theory and group dynamics. This experience with the fundamental principles of systems organization and dynamics will serve the teacher both as a member of the instructional system, and in understanding the social systems in which the student and the instructional system are imbedded.

An understanding of group dynamics is mandatory for effective participation in the counseling, consulting and group leadership processes.

To supplement and complement the above program at the college level, an intensive effort must be made at the in-servic teacher training level. This effort is required to supplement the college experience for new teachers, and to provide the equivalent of the new college experience for teachers already on the job. Therefore, it will be necessary to provide in-service training in the areas identified above for college. In addition, the following categories of in-service courses will be required:

1. Training in the specifics of management and operation of the Phase II instructional system. This training will include orientation to the system as well as development of the specific skills demanded of the system.
2. Specific media and instructional materials so mediated in the system will impose training requirements on all teachers entering the system. This training will include familiarization with the materials to a degree of competence that will permit the teacher to function as an expert counsultant to the student.
3. Specific systems analysis techniques should be incorporated in the in-service program for a variety of reasons. Although the new teacher should be thoroughly grounded in systems theory, it is unlikely that he will function in this capacity within the instructional system for some years. To facilitate adjustment to the teaching role, training in systems analysis should be postponed until sufficient maturity and experience has been achieved by the teacher.
4. For similar reasons to those advanced for systems analysis training, the in-service training of managers should be provided immediately prior to the assignment of teachers to this increased responsibility. In this situation the teacher must be trained in the particular mechanics of management within the system.